4.2 Surface Water and Sediment Surveillance

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Surface water and sediment on and near the Hanford Site are monitored to determine the potential impacts of Hanford-originated radiological and chemical contaminants to the public and to the aquatic environment. Surface-water bodies included in routine surveillance are the Columbia River, riverbank springs, onsite ponds, and offsite water systems directly east and across the Columbia River from the Hanford Site. Sediment quality surveillance is conducted on the Columbia River and riverbank springs. Tables 4.2.1 and 4.2.2 summarize the sampling locations, sample types, sampling frequencies, and sample analyses included in surface-water and sediment surveillance activities during 1995. Sample locations are also identified in Figure 4.2.1. This section describes the surveillance effort and summarizes the results for these aquatic environments. Detailed analytical results are reported by Bisping (1996).

Columbia River Water

The Columbia River is the second largest river in the continental United States in terms of total flow, and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production and processing was based, in part, on the abundant water supply offered by the river. The Columbia River flows through the northern edge of the Site and forms part of the Site's eastern boundary. The river is used as a source of drinking water for onsite facilities and by communities located downstream from the Hanford Site. Water from the Columbia River downstream of Site operations is also used extensively for crop irrigation. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water-skiing, and swimming.

Originating in the mountains of eastern British Columbia, Canada, the Columbia River drains a total area of approximately 70,800 km^2 (27,300 mi^2) en route to the Pacific Ocean. Its flow is regulated by 11 dams within the United States, seven upstream and four downstream of the Site. Priest Rapids is the nearest dam upstream, and McNary is the nearest dam downstream from the Site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam), near Richland. The Hanford Reach is the last stretch of the Columbia River in the United States above Bonneville Dam that remains unimpounded. The Hanford Reach is currently under consideration for designation as a National Wild and Scenic River as a result of congressional action in 1988.

Flows through the Hanford Reach fluctuate significantly and are controlled primarily by operations at Priest Rapids Dam. Annual flows of the Columbia River below Priest Rapids Dam over the last 77 years have averaged nearly 3,360 m^3/s (120,000 ft^3/s) (Wiggins et al. 1995). The annual average flow rate below Priest Rapids Dam in 1995 was 3,206 m^3/s (113,219 ft^3/s). The peak monthly average flow rate in 1995 occurred during December (4,624 m^3/s [163,295 ft^3/s]), following a rapid snow melt preceded by a large winter storm (Figure 4.2.2). A secondary high occurred in June as a result of spring runoff. The lowest monthly average flow rate occurred during September (2,040 m^3/s [72,042 ft^3/s]). Daily average flow rates varied from 1,339 to 5,805 m^3/s (47,286 to 205,002 ft^3/s) during 1995. As a result of fluctuations in discharges, the depth of the river varies significantly over time. River stage may change along the Reach by up to 3 m (10 ft) within a few hours (Dresel et al. 1996). Seasonal changes of about the same magnitude are also observed. River stage fluctuations measured at the 300 Area are only about half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (Campbell et al. 1993), and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 300 m (984 ft) to 1,000 m (3,281 ft) along the Hanford Site.

Pollutants, both radiological and nonradiological, are known to enter the Columbia River along the Hanford Reach. In addition to direct discharges of liquid effluents from Hanford facilities, contaminants in ground water from past discharges to the ground are known to

Table 4.2.1. Surface-Water Surveillance, 1995

Location	Sample Type	Frequency[a]	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland	Cumulative	M Comp[b]	Alpha, beta, lo ^{3}H,[c] gamma scan, ^{90}Sr, ^{99}Tc, U[d]
Priest Rapids Dam and Richland	Particulate (filter)	M Cont [e] Q Cont	Gamma scan Pu[f]
Priest Rapids Dam and Richland	Soluble (resin)	M Cont Q Cont	Gamma scan ^{129}I, Pu
Vernita Bridge and Richland	Grab (transects)	Q	lo ^{3}H, ^{90}Sr, U
100-F and 300 Area	Grab (transects)	A	lo ^{3}H, ^{90}Sr, U
100-N	Grab (transects)	A	Alpha, beta, lo ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan
Hanford Townsite	Grab (transects)	A	lo ^{3}H, ^{90}Sr, ^{99}Tc, U
Columbia River - Nonradiological			
Vernita and Richland[g]	Grab	Q	WQ-NASQAN, temperature, dissolved oxygen, turbidity, pH, fecal coliforms, suspended solids, dissolved solids, conductivity, hardness as $CaCO_3$, P, Cr, N-Kjeldahl, Fe, NH_3, NO_3 + NO_2
Vernita and Richland	Grab (transects)	Q	ICP[h] metals, anions, volatile organics, As, Pb
Vernita and Richland	Grab (transects)	A	CN, Hg
100-N, 100-F, and Hanford Townsite	Grab (transects)	A	ICP metals, anions, volatile organics, As, Pb
300 Area	Grab (transects)	A	ICP metals, anions, volatile organics, As, Pb, CN
Onsite Ponds			
West Lake	Grab	Q	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan
B Pond	Grab	Q	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, gamma scan
FFTF Pond	Grab	Q	Alpha, beta, ^{3}H, gamma scan
Offsite Water			
Drinking water	Grab	A	Alpha, beta, ^{3}H, U, gamma scan
Riverview Canal	Grab	3[i]	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma scan
Riverbank Springs			
100-B, 100-K, 100-N, and 100-H	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions, volatile organics
100-D	Grab	2[j]	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions, volatile organics
Hanford Townsite and 300 Area	Grab	A	Alpha, beta, ^{3}H, ^{129}I, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions, volatile organics

(a) A = annually; M = monthly; Q = quarterly; Comp = composite.
(b) M Comp indicates river water was collected hourly and composited monthly for analysis.
(c) lo ^{3}H = low-level tritium analysis.
(d) Isotopic uranium.
(e) M/Q Cont indicates river water was sampled by continuous flow through a filter and resin column and composited monthly (M) or quarterly (Q) for analysis.
(f) Isotopic plutonium.
(g) Numerous water quality analyses are performed by the U.S. Geological Survey (USGS) in conjunction with the National Stream Quality Accounting Network (NASQAN) Program. Thermograph stations are operated and maintained by the USGS.
(h) ICP = inductively coupled plasma analysis method.
(i) Three samples during irrigation season.
(j) Two samples during period of low river flow (August-September).

Table 4.2.2. Sediment Surveillance, 1995

Location[a]	Frequency	Analyses
River		
McNary Dam		
Oregon shore	A[b]	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
1/3 from Oregon shore	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
2/3 from Oregon shore	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
Washington shore	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
Priest Rapids Dam		
Grant County shore	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
1/3 from Grant County shore	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
2/3 from Grant County shore	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
Yakima County shore	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
White Bluffs Slough	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
100-F Slough	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
Hanford Slough	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
Richland	A	Gamma scan, ^{90}Sr, U,[c] Pu,[d] Pb, ICP[e] Metals
Springs		
100-B Spring	A	Gamma scan, ^{90}Sr, U,[c] ICP[e] Metals
Hanford Spring 28-2	A	Gamma scan, ^{90}Sr, U,[c] ICP[e] Metals
300 Area Spring 42-2	A	Gamma scan, ^{90}Sr, U,[c] ICP[e] Metals
100-K Spring	A	Gamma scan, ^{90}Sr, U,[c] ICP[e] Metals
100-F Spring	A	Gamma scan, ^{90}Sr, U,[c] ICP[e] Metals, Pb

(a) See Figure 4.2.1.
(b) A = annually.
(c) Includes ^{235}U and ^{238}U analyzed by low-energy photon analysis.
(d) Isotopic plutonium.
(e) Inductively coupled plasma analysis method.

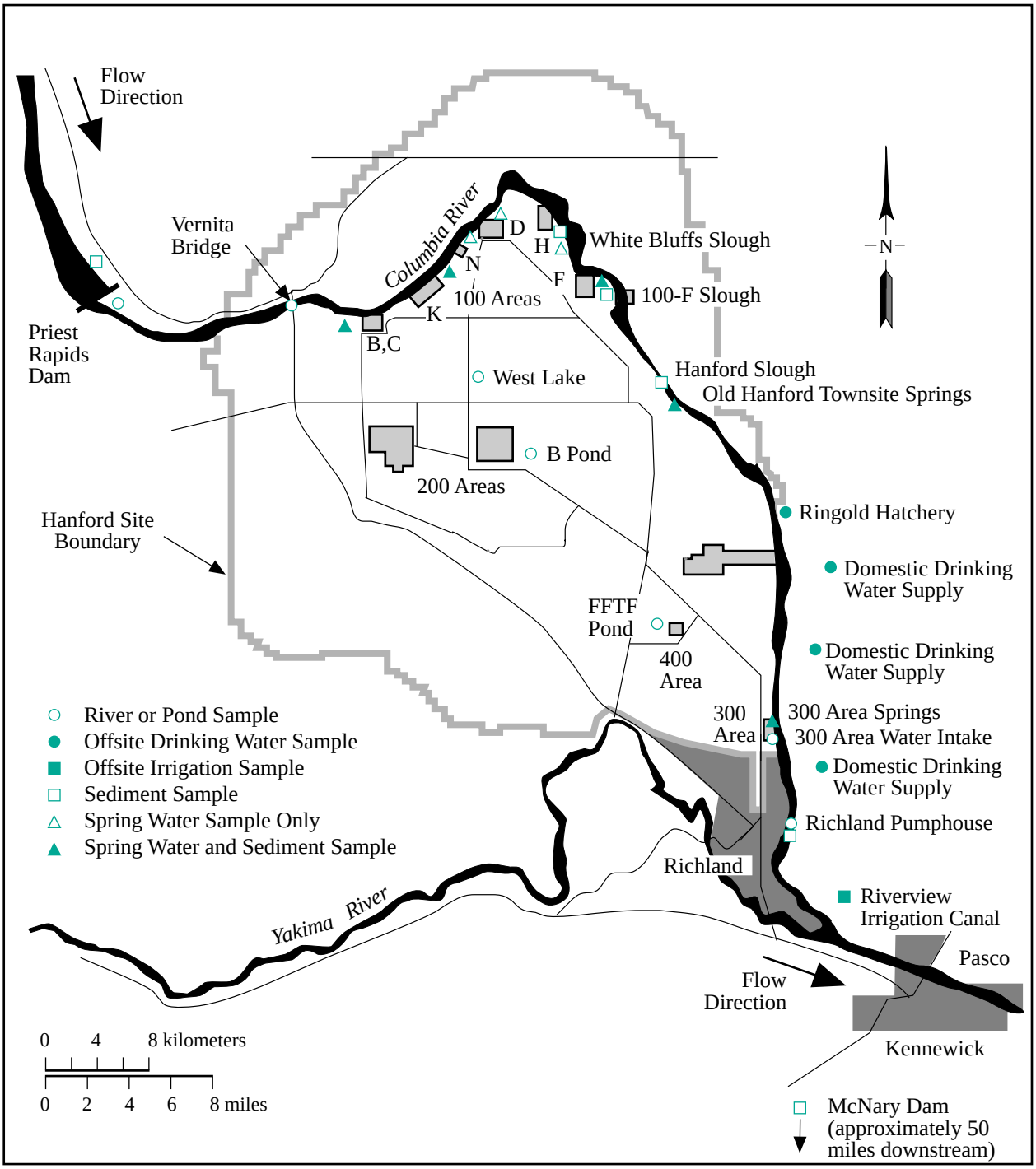

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Figure 4.2.1. Water and Sediment Sampling Locations, 1995

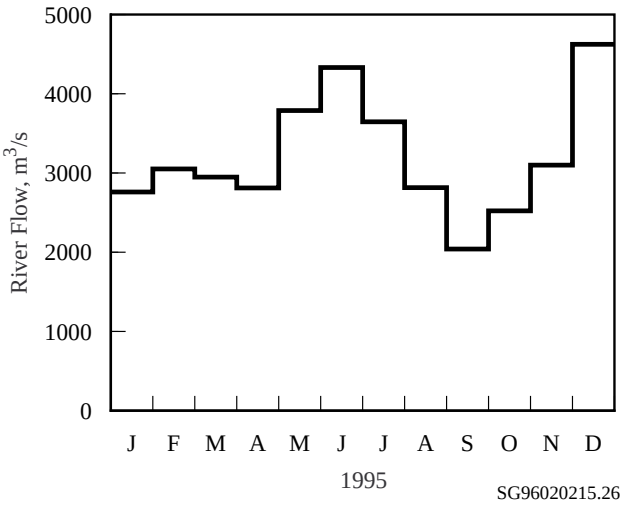

Figure 4.2.2. Mean Monthly Columbia River Flow Rates During 1995 (measured at Priest Rapids Dam)

seep into the river (Dirkes 1990, DOE 1992e, McCormack and Carlile 1984, Peterson 1992). Effluents from each direct discharge point are routinely monitored and reported by the responsible operating contractor; these are summarized in Section 3.1, "Facility Effluent Monitoring." Direct discharges are identified and regulated for nonradiological constituents under the National Pollutant Discharge Elimination System in compliance with the Clean Water Act. The National Pollutant Discharge Elimination System-permitted discharges at Hanford are summarized in Section 2.2, "Compliance Status."

The state of Washington has classified the stretch of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (Ecology 1992). Water quality criteria and water use guidelines have been established in conjunction with this designation and are provided in Appendix C, Table C.1.

Collection and Analysis of River Water Samples

Samples of Columbia River water were collected throughout 1995 at the locations shown in Figure 4.2.1. Samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse, and from Columbia River transects established near the Vernita Bridge, 100-N Area, 100-F Area, old Hanford Townsite, 300 Area, and the Richland Pumphouse. Samples were collected upstream from Hanford facilities at Priest Rapids Dam and the Vernita Bridge to provide background data from locations unaffected by Site operations. Samples were collected from all other locations to identify any increase in contaminant concentrations attributable to Hanford operations. The Richland Pumphouse is the first downstream point of river water withdrawal for a public drinking water supply.

The fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse consisted of both an automated sampler and a continuous flow system. Using the automated sampler, unfiltered samples of Columbia River water (cumulative samples) were collected hourly and composited monthly for radiological analyses (Table 4.2.1). Using the continuous flow system, particulate and soluble fractions of select Columbia River water constituents were collected in a filter and resin column, respectively. Filter and resin samples were composited monthly or quarterly for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in detail in the *Environmental Monitoring Plan* (DOE 1994a).

A deviation from the environmental monitoring plan occurred from mid-March 1995 through early January 1996 due to construction at the Richland Pumphouse, which necessitated the removal of composite and continuous river water sampling equipment. Continuous-flow filter and resin samples of Columbia River water at the Richland Pumphouse were not collected during this time. Automated hourly grab samples of Columbia River water were replaced by manual weekly grab samples from the boat dock adjacent to the pumphouse and were composited monthly for analysis.

Radiological analyses of water samples collected from the Priest Rapids Dam and Richland Pumphouse fixed-location monitoring stations included total alpha, total beta, gamma scan, tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, and -238, plutonium-238, and plutonium-239,240. Alpha and beta measurements provided a general indication of radioactive contamination. Gamma scans provided the ability to detect numerous specific radionuclides (Appendix E). Sensitive radiochemical analyses and, in some cases, special sampling techniques were used to determine the concentrations of tritium, strontium-90, technetium-99, iodine-129, uranium-234, -235, and -238, plutonium-238, and plutonium-239,240 in river water during the year. Radionuclides of interest were selected for analysis based on their presence in effluents discharged from Site facilities or in near-shore ground-water underlying the Hanford Site, and their importance in determining water

quality, verifying effluent control and effluent monitoring systems, and determining compliance with applicable standards. Analytical detection levels for all radionuclides were less than 10% of their respective ambient water quality criteria levels (Appendix C, Table C.1).

Transect sampling was initiated as a result of findings of a special study conducted during 1987 and 1988 (Dirkes 1993). This study concluded that, under certain flow conditions, contaminants entering the river from Hanford are not completely mixed at routine Pacific Northwest National Laboratory river monitoring stations. Incomplete mixing results in a slight conservative bias in the data generated using the routine single-point sampling systems at the 300 Area (see Section 4.3, "Hanford Site Drinking Water Surveillance") and the Richland Pumphouse. The cross sections at Vernita Bridge and the Richland Pumphouse were sampled quarterly during 1995. Annual transect sampling was conducted at the 100-N Area, 100-F Area, old Hanford Townsite, and 300 Area sampling locations.

Columbia River transect water samples collected in 1995 were analyzed for both radiological and chemical contaminants (Table 4.2.1). Metals, anions, and volatile organics, listed in DOE (1994c), were selected for analysis following reviews of existing surface- and ground-water data, various Remedial Investigation/Feasibility Study work plans, and preliminary Hanford Site risk assessments (Blanton et al. 1995b, Dirkes et al. 1993, DOE 1992b, Evans et al. 1992, Napier et al. 1995). All radiological and chemical analyses of transect samples were performed on unfiltered water.

In addition to Columbia River monitoring conducted by Pacific Northwest National Laboratory in 1995, nonradiological water quality monitoring was also performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network program. During 1995, U.S. Geological Survey samples were collected along Columbia River transects quarterly at the Vernita Bridge and three times at the Richland Pumphouse. Sample analyses were performed at the U.S. Geological Survey laboratory in Denver, Colorado for numerous physical, biological, and chemical constituents.

Radiological Results for Columbia River Water Samples

Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and the Richland Pumphouse during 1995 are reported by Bisping (1996) and summarized in Appendix A, Tables A.1 and A.3. Samples of Columbia River water were also collected by the Drinking Water Monitoring Program in 1995 at the 300 Area water intake. The 300 Area radiological monitoring results are reported in Section 4.3, "Hanford Site Drinking Water Surveillance," and are summarized in Appendix A, Table A.2. Tables A.1 through A.3 list the maximum and mean concentrations of select radionuclides observed in Columbia River water in 1995 and during the previous 5 years. All radiological contaminant concentrations measured in Columbia River water in 1995 were less than DOE Derived Concentration Guides and state of Washington ambient surface water quality criteria levels (Appendix C, Tables C.5 and C.1, respectively). Significant results are discussed and illustrated below, and comparisons to previous years are provided.

Levels of radionuclides monitored in Columbia River water were extremely low throughout the year. Radionuclides consistently detected in river water collected from monitoring stations during 1995 at concentrations greater than two times their total propagated analytical uncertainty included tritium, strontium-90, iodine-129, uranium-234, and -238, and plutonium-239,240. The concentrations of all other measured radionuclides were less than two times their respective total propagated analytical uncertainties, and so were essentially not detectable in over 75% of samples collected. Tritium, strontium-90, iodine-129, and plutonium-239,240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford effluents.

Total alpha and total beta measurements are useful indicators of the general radiological quality of the river and provide an early indication of changes in the levels of radioactive contamination because results are obtained quickly. Figures 4.2.3 and 4.2.4 illustrate the average annual total alpha and total beta concentrations, respectively, at Priest Rapids Dam and the Richland Pumphouse during the past 6 years. The 1995 average total alpha and total beta concentrations were similar to those observed during recent years. Monthly total alpha and total beta concentrations measured at the Richland Pumphouse in 1995 were not significantly different (paired sample comparison and t-test of differences, 5% significance level) from those measured at Priest Rapids Dam. The average total alpha and beta concentrations in Columbia River water at Priest Rapids Dam and the Richland

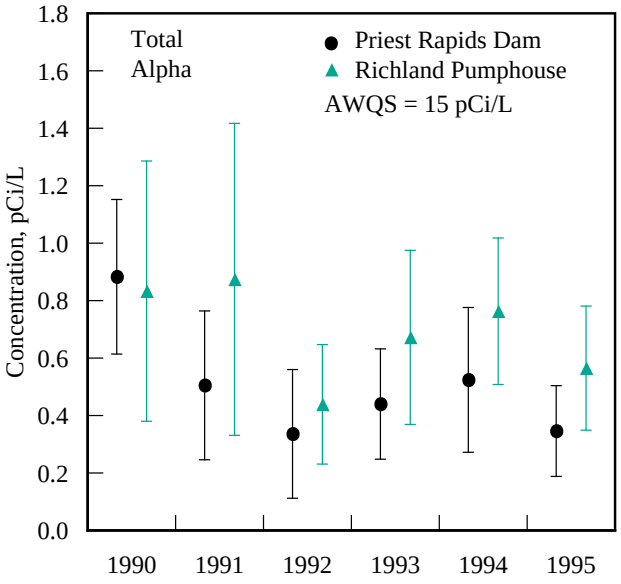

Figure 4.2.3. Annual Average Total Alpha Concentrations (±2 standard error of the mean) in Columbia River Water, 1990 Through 1995

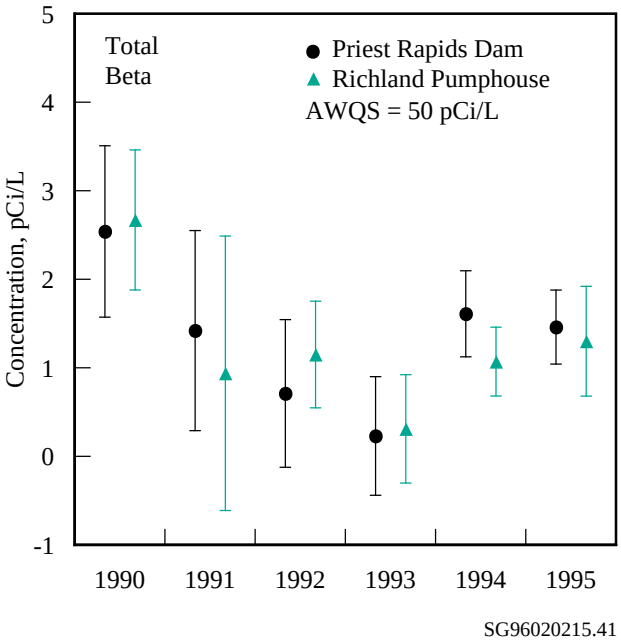

Figure 4.2.4. Annual Average Total Beta Concentrations (±2 standard error of the mean) in Columbia River Water, 1990 Through 1995

Pumphouse in 1995 were less than 5% of their respective Washington State ambient surface water quality criteria levels of 15 and 50 pCi/L.

Figure 4.2.5 compares the average annual tritium concentrations at Priest Rapids Dam and the Richland Pumphouse from 1990 through 1995. The general decline in tritium concentrations in river water noted during the late 1980s remains evident at both locations. Statistical analysis (paired sample comparison, t-test of differences, 5% significance level) indicated that monthly tritium concentrations in river water at the Richland Pumphouse were significantly higher than those at Priest Rapids Dam. Onsite sources of tritium entering the river include groundwater seepage and direct discharge from outfalls located in the 100 Area (see Section 3.1, "Facility Effluent Monitoring," and Section 5.8, "Ground-Water Protection and Monitoring Program"). Tritium concentrations measured at the Richland Pumphouse, while representative of river water used by the City of Richland for drinking water, tend to overestimate the average concentrations of tritium in the river at this location (Dirkes 1993). This bias is attributable to the contaminated 200 Area ground-water plume entering the river along the portion of shoreline extending from the old Hanford Townsite to below the 300 Area, which is relatively close to the

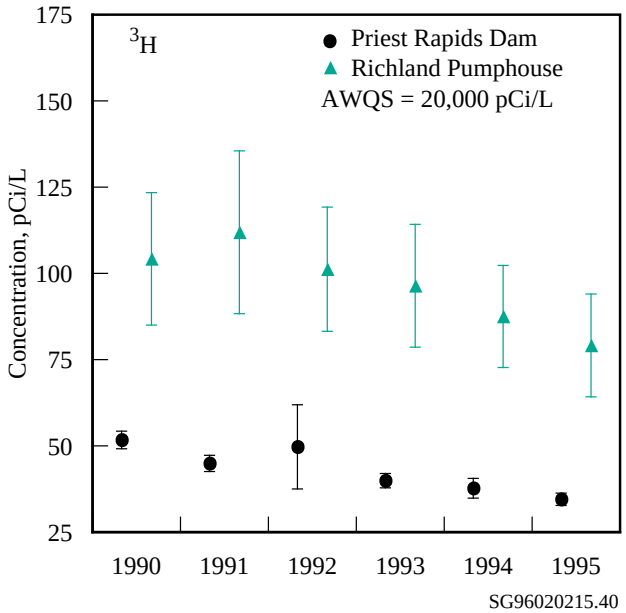

Figure 4.2.5. Annual Average Tritium Concentrations (±2 standard error of the mean) in Columbia River Water, 1990 Through 1995. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Richland sample intake. This plume is not completely mixed within the river at the Richland Pumphouse. Sampling along a cross section at the Richland Pumphouse during 1995 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken from the Richland Pumphouse overestimate the average tritium concentrations in the Columbia River at this location is highly variable and appears to be related to the flow rate of the river just before and during sample collection. Average tritium concentrations in Columbia River water collected from Priest Rapids Dam and the Richland Pumphouse during 1995 were less than 1% of the state of Washington ambient surface water quality criteria level of 20,000 pCi/L.

The average annual strontium-90 concentrations of Columbia River water collected from Priest Rapids Dam and the Richland Pumphouse from 1990 through 1995 are presented in Figure 4.2.6. Concentrations observed in 1995 were similar to those observed previously. Ground-water plumes containing strontium-90 enter the Columbia River throughout the 100 Areas (Dresel et al. 1996). The highest strontium-90 concentrations in ground water onsite have been found in the 100-N Area as a result of past discharges to the 100-N liquid waste disposal facilities. Despite the Hanford source, the differences between monthly strontium-90 concentrations at Priest Rapids Dam and the Richland Pumphouse in 1995 were not significant (paired sample comparison, t-test of differences, 5% significance level). Average strontium-90 concentrations in Columbia River water were approximately 1% of the state of Washington ambient surface water quality criteria level of 8 pCi/L.

Average annual total uranium concentrations (i.e., the sum of uranium-234, -235, and -238 concentrations) at the Richland Pumphouse and Priest Rapids Dam for 1990 through 1995 are shown in Figure 4.2.7. The large error associated with 1994 results was attributed to an unusually low concentration found in the December sample of each location. Total uranium concentrations observed in 1995 were similar to those observed during recent years. Monthly total uranium concentrations measured at the Richland Pumphouse in 1995 were significantly higher than those measured at Priest Rapids Dam (paired sample comparison, t-test of differences, 5% significance level). Although there is no direct

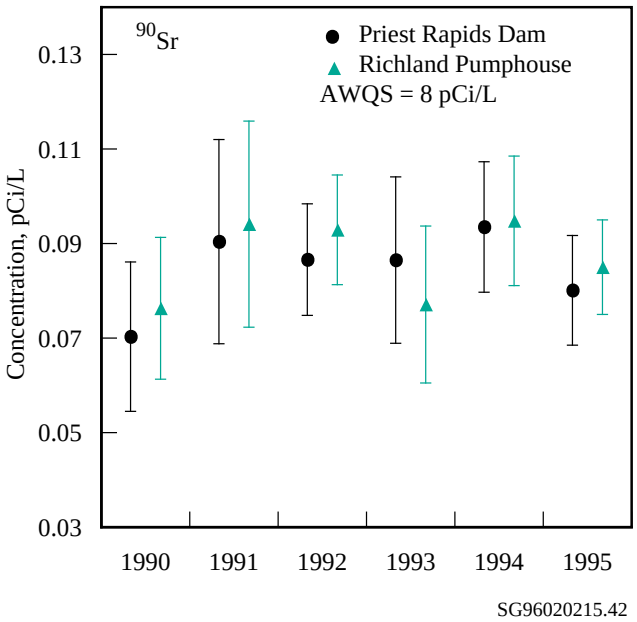

Figure 4.2.6. Annual Average Strontium-90 Concentrations (±2 standard error of the mean) in Columbia River Water, 1990 Through 1995

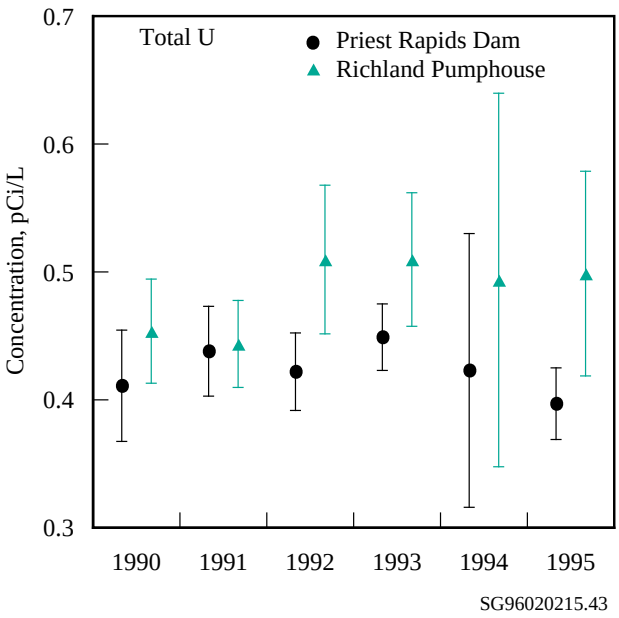

Figure 4.2.7. Annual Average Total Uranium (Uranium-234 + Uranium-235 + Uranium-238) Concentrations (±2 standard error of the mean) in Columbia River Water, 1990 Through 1995

discharge of uranium to the river, uranium is present in the ground water beneath the 300 Area as a result of past Hanford operations (see Section 5.8, "Ground-Water Protection and Monitoring Program") and has been detected at elevated levels in riverbank springs in this area (see Riverbank Springs subsection). Naturally occurring uranium is also known to enter the river across from Hanford via irrigation return water and ground-water seepage associated with extensive irrigation north and east of the Columbia River (Dirkes 1990). There are currently no ambient surface water quality criteria levels directly applicable to uranium. However, total uranium concentrations in the river during 1995 were well below the proposed EPA Drinking Water Standard of 20 µg/L (30 pCi/L).

Figure 4.2.8 presents the average annual iodine-129 concentrations (aCi/L) for Priest Rapids Dam and the Richland Pumphouse for 1990 through 1995. The large error observed at Priest Rapids Dam in 1994 is attributable to an unusually high third quarter result at that location. Only one quarterly iodine-129 result is available for the Richland Pumphouse during 1995 due to construction activities at the pumphouse. That single result is plotted in Figure 4.2.8 with its associated analytical uncertainty. The average concentration of iodine-129 in Columbia River water was extremely low during 1995 (less than one-tenth of 1% of the Washington State ambient surface water quality criteria level of 1 pCi/L [1,000,000 aCi/L]) and similar to levels observed during recent years. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated ground water along the portion of shoreline downstream of the old Hanford Townsite (Section 4.8, "Ground-Water Protection and Monitoring Program"). The iodine-129 plume originated in the 200 Area from past waste disposal practices. Due to the removal of continuous river sampling equipment at the Richland Pumphouse from March through December 1995, there were insufficient data to make a statistical comparison of iodine-129 concentrations in Columbia River water at the Richland Pumphouse and Priest Rapids Dam. With the exception of 1994 results, the quarterly iodine-129 concentrations at the Richland Pumphouse have been significantly higher than those at Priest Rapids Dam (paired sample comparison, t-test of differences, 5% significance level) (Dirkes and Hanf 1995, Dirkes et al. 1994).

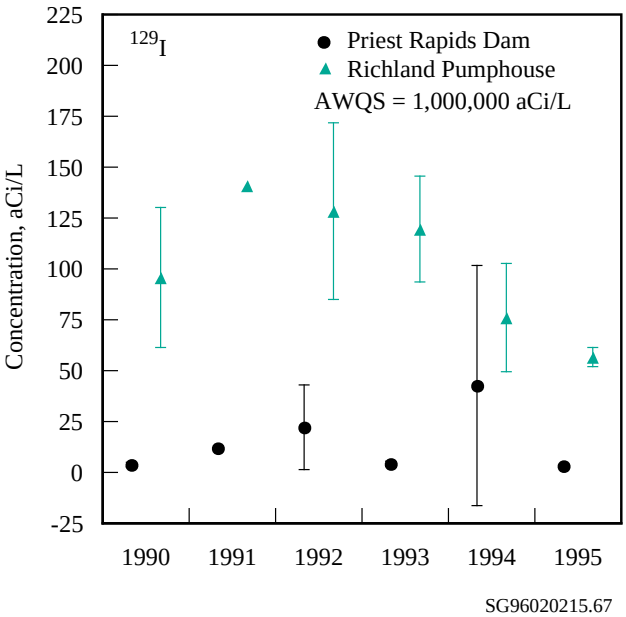

Figure 4.2.8. Annual Average Iodine-129 Concentrations (±2 standard error of the mean) in Columbia River Water, 1990 Through 1995. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbols.

During 1995, average plutonium-239,240 concentrations at Priest Rapids Dam and the Richland Pumphouse were 57.4 ± 40.2 aCi/L and 80.4 ± 73.8 aCi/L, respectively. Note that, due to construction activities, only one quarterly sample for plutonium analysis was collected at the Richland Pumphouse in 1995. No ambient surface water quality criteria levels currently exist for plutonium-239 or plutonium-240; however, if the DOE Derived Concentration Guides (Appendix C, Table C.5), which are based on a 100-mrem dose standard, are converted to a 4-mrem dose equivalent used to develop the Drinking Water Standards and ambient surface water quality criteria levels, 1.2 pCi/L (1,200,000 aCi/L) would be the relevant guideline for both plutonium-239 and plutonium-240. Due to the removal of continuous river sampling equipment at the Richland Pumphouse from March through December 1995, there were insufficient data to make a statistical comparison of plutonium-239,240 concentrations in Columbia River water at the Richland Pumphouse and Priest Rapids Dam. Historically, the difference in plutonium-239,240 concentrations at these locations has not been significant (paired sample comparison, t-test of differences, 5% significance level) (Dirkes and Hanf 1995).

Radiological results of samples collected along cross sections of the Columbia River established at the Vernita Bridge, 100-N Area, 100-F Area, old Hanford Townsite, 300 Area, and the Richland Pumphouse during 1995 are presented in Appendix A, Table A.4 and in Bisping (1996).

Constituents that were consistently detected (in greater than 50% of river transect samples) at concentrations greater than two times their associated total propagated analytical uncertainty included tritium, strontium-90, and uranium-234, and -238. All measured radionuclide concentrations were less than applicable ambient surface water quality criteria levels.

Mean tritium concentrations measured along cross sections of the Columbia River during 1995 are depicted in Figure 4.2.9. The reported result is plotted for those transects that were sampled only once in 1995. The transects are displayed such that the observer's view is downstream. Vernita Bridge is the most upstream transect. Stations 1 and 10 are located along the Benton County and Franklin/Grant Counties shorelines, respectively. The highest mean tritium concentrations observed in 1995 river transect water (Figure 4.2.9) were detected along the shoreline of the old Hanford Townsite where ground water containing tritium concentrations in excess of the ambient surface water quality criteria level of 20,000 pCi/L is known to discharge to the river (Dresel et al. 1996). The highest overall tritium concentration, however, was detected along the shoreline of the Richland Pumphouse in March. Elevated levels of tritium were also evident near the Hanford shoreline at the 100-N Area and 300 Area transect locations. The presence of a tritium concentration gradient in the Columbia River at the Richland Pumphouse supports previous conclusions made by Backman (1962) and Dirkes (1993) that contaminants in the 200 Area ground-water plume entering the river at, and upstream of, the 300 Area are not completely mixed at the Richland Pumphouse. The gradient is most pronounced during periods of relatively low flow. As noted since transect sampling was initiated in 1987, the mean concentration of tritium measured along the cross section established at the Richland Pumphouse was less than that measured in monthly composited samples from the pumphouse, illustrating the conservative bias of the fixed-location monitoring station.

Mean strontium-90 levels in 1995 transect samples were fairly uniform across the width of the river and varied little between transects. Four slightly elevated results (maximum of 0.476 pCi/L) were reported along the Richland Pumphouse transect during 1995. These anomalies occurred sporadically in both time and space; no trends in strontium-90 distribution were noted.

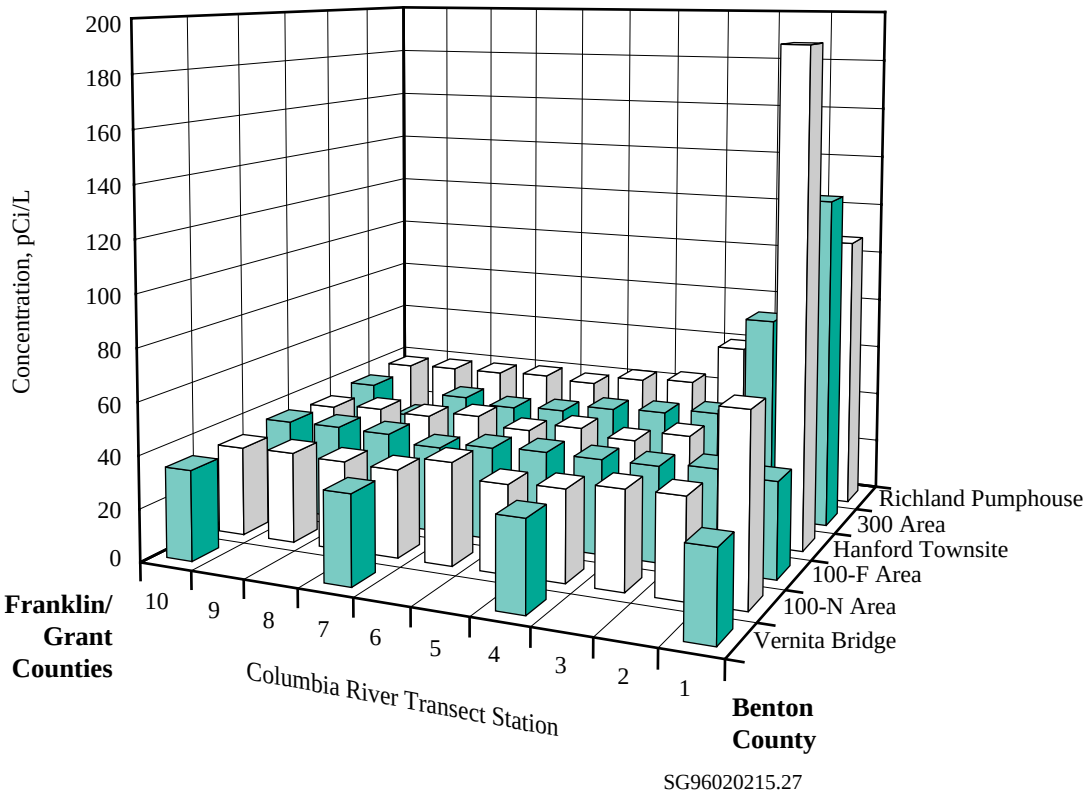

Figure 4.2.9. Mean Tritium Concentrations in Columbia River Transects During 1995

Reanalyses of the samples in question were not possible. The mean concentration of strontium-90 found during cross-sectional sampling at the Richland Pumphouse was similar to that measured in monthly-composited samples from the pumphouse. The similarity indicates that strontium-90 concentrations in water collected from the fixed-location monitoring station are representative of the average strontium-90 concentration of the river at this location.

Total uranium concentrations (i.e., the sum of uranium-234, -235, and -238 concentrations) in 1995 were elevated along both the Benton and Franklin County shorelines of the 300 Area and Richland Pumphouse transects. The highest total uranium concentration was measured near the Franklin County shoreline of the Richland Pumphouse transect and likely resulted from ground-water seepage, and irrigation return canals east of the river that contained naturally-occurring uranium (Dirkes 1990). The mean concentration of total uranium across the Richland Pumphouse transect was similar to that measured in monthly-composited samples from the pumphouse.

Nonradiological Results for Columbia River Water Samples

Nonradiological water quality data were compiled by the Pacific Northwest National Laboratory and the U.S. Geological Survey during 1995. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and/or Hanford-originated contaminants. Potential sources of pollutants not associated with Hanford include irrigation return water and ground-water seepage associated with extensive irrigation north and east of the Columbia River (Dirkes 1990).

Figure 4.2.10 shows the preliminary Vernita Bridge and the Richland Pumphouse U.S. Geological Survey results for 1990 through 1995 for several water quality parameters with respect to their applicable standards. In accordance with Washington State water quality standards (Appendix C, Table C.1), fecal coliform results are presented as annual geometric means (i.e., the antilogarithm of the arithmetic mean of the logarithms of the individual sample values). Turbidity and dissolved oxygen results are presented as annual arithmetic means. The complete list of preliminary results obtained through the U.S. Geological Survey National Stream Quality Accounting Network program is documented in Bisping (1996) and is summarized in Appendix A, Table A.5. Final results will be published by the U.S. Geological Survey in an annual report entitled "Water Resources Data Washington Water Year 1995" (Wiggins et al. 1996). The 1995 U.S. Geological Survey results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface-water body were met; however, the minimum detectable concentration of silver exceeded the Washington State acute toxicity standard. During 1995, there was no indication of any deterioration of water quality resulting from Hanford operations along the Hanford Reach of the Columbia River.

Results of nonradiological sampling conducted by Pacific Northwest National Laboratory along cross sections of the Columbia River in 1995 at the Vernita Bridge, 100-N Area, 100-F Area, old Hanford Townsite, 300 Area, and the Richland Pumphouse are provided by Bisping (1996). The concentrations of volatile organics, metals, and anions observed in river water in 1995 were similar to those observed in the past. Volatile organic compounds were not routinely detected; those that were detected in greater than 5% of samples collected in 1995 included toluene and trichloroethylene. Neither compound displayed elevated concentrations along the Hanford shoreline of the Columbia River. All volatile organic compound concentrations were less than EPA ambient surface water quality criteria levels.

Several metals and anions were detected both upstream and downstream of the Hanford Site at levels comparable to those reported by the U.S. Geological Survey as part of their ongoing National Stream Quality Accounting Network program. The highest concentrations of most metals were detected during periods of relatively high river flow and were most likely associated with elevated levels of suspended sediment. Copper concentrations were slightly elevated along the Benton County shoreline of the 300 Area transect. Lead and zinc concentrations were elevated along the Benton County shoreline of the Richland Pumphouse transect during relatively low river flow in June. Nitrate concentrations were elevated along the Franklin County shoreline of the old Hanford Townsite, 300 Area, and Richland Pumphouse transects and likely resulted from ground-water seepage associated with extensive irrigation north and east of the Columbia River. Ground-water nitrate contamination associated with high fertilizer and water usage in Franklin County has been documented by the U.S. Geological Survey (1995). Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate. With the exception of nitrate, which had the highest average quarterly concentration at the Richland Pumphouse, no consistent differences were found between

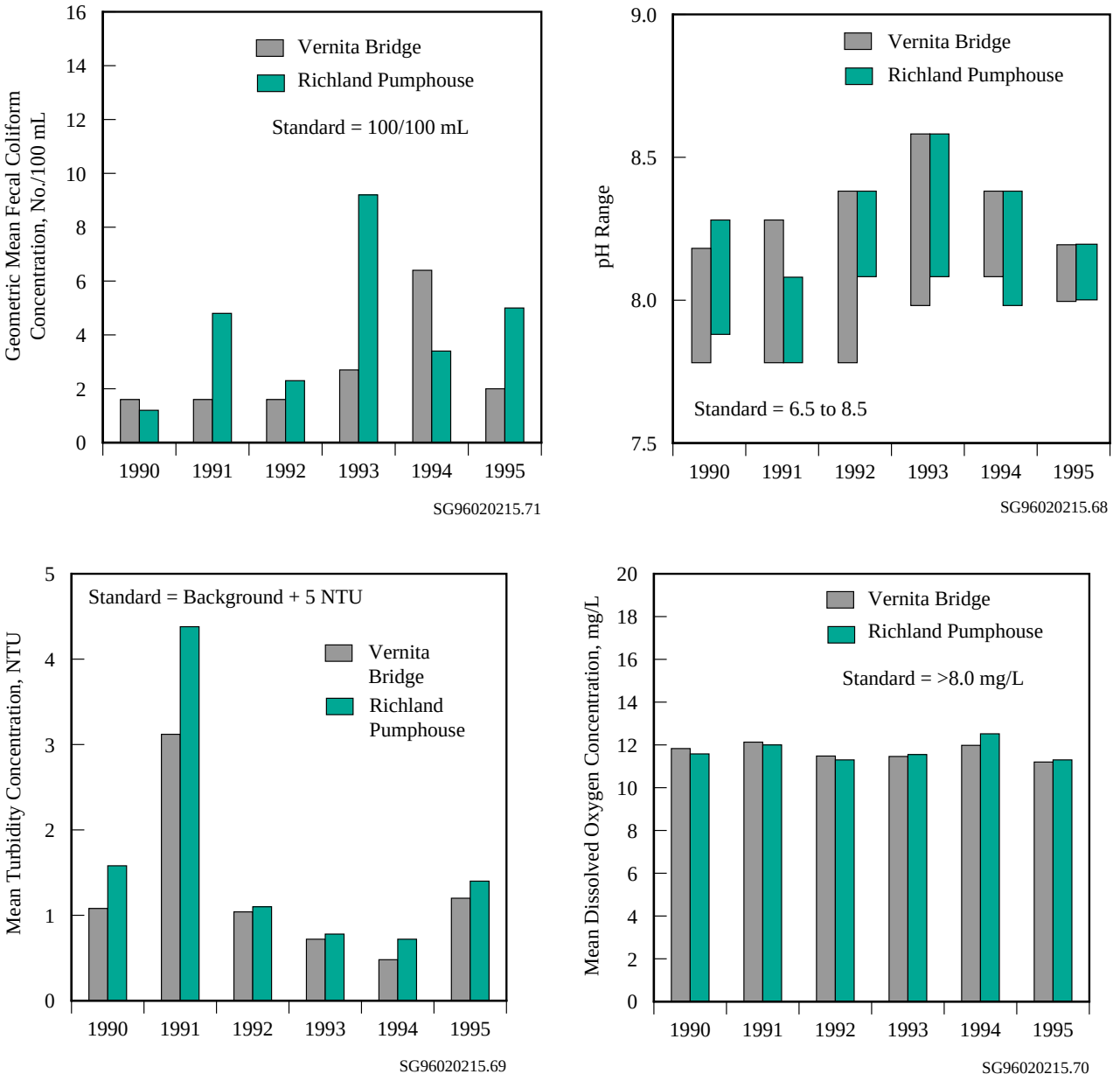

Figure 4.2.10. Preliminary USGS Columbia River Water Quality Measurements, 1990 Through 1995

average quarterly contaminant concentrations in the Vernita Bridge and Richland Pumphouse transect samples.

Washington State ambient surface water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total hardness-dependent (Appendix C, Table C.3). Criteria for Columbia River water were calculated using a total hardness of 51 mg/L as $CaCO_3$, the limiting value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and the Richland Pumphouse over the past six years. The total hardness concentration reported by the U.S. Geological Survey at those locations from 1990 through 1995 ranged from 51 to 77 mg/L as $CaCO_3$. All metal and anion concentrations in river water were less than Washington State ambient surface water quality criteria levels for acute toxicity. However, chronic toxicity levels for lead were exceeded in all Columbia River transect samples with the exception of those collected along the 300 Area transect. Note that the chronic toxicity criteria for lead are based on a

4-day average concentration not to be exceeded more than once every 3 years; transect samples are grab samples and are therefore not directly comparable to the standard. The minimum detectable concentrations of antimony and arsenic exceeded EPA standards to protect human health for the consumption of water and organisms. The minimum detectable concentrations of cadmium and mercury exceeded chronic toxicity standards; that of silver exceeded the acute toxicity standard. Measures have been taken to ensure that analytical procedures capable of achieving adequate method detection levels for antimony, cadmium, and mercury will be employed on all 1996 Columbia River samples. Silver has not been identified as a Hanford-originated contaminant of concern to the Columbia River (Blanton et al. 1995b, Napier et al. 1995); no steps have been taken to lower its method detection level.

Columbia River Sediments

Sediments in the Columbia River contain low levels of radionuclides and metals of Hanford origin as well as radionuclides from nuclear weapons testing fallout (Beasley et al. 1981, Robertson and Fix 1977, Woodruff et al. 1992, Blanton et al. 1995b). Public exposures are well below the level at which routine surveillance of Columbia River sediments is required (Sula 1980, Wells 1994). However, periodic sampling is necessary to confirm the low levels and to ensure that no significant changes have occurred over time that may increase the potential exposure to the public through this pathway. The accumulation of radioactive materials in sediment can lead to human exposure through ingestion of aquatic species, through sediment resuspension into drinking water supplies, or as an external radiation source irradiating people who are fishing, wading, sunbathing, or participating in other recreational activities associated with the river and/or shoreline (DOE 1991).

As a result of past operations at the Hanford Site, large quantities of radioactive and nonradioactive materials were discharged to the Columbia River. On release to the river, the materials were dispersed rapidly, sorbed onto detritus and inorganic particles, incorporated into aquatic biota, and/or deposited on the riverbed as sediment. Fluctuations in the river flow rate, as a result of the operation of hydroelectric dams, annual spring freshets, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the contaminated sediments (DOE 1994a).

Since the shutdown of the original single-pass cooling reactors, the contaminant burden in the surface sediments has been decreasing as a result of radioactive decay and the subsequent deposition of uncontaminated material. However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via direct liquid effluent discharges from Hanford facilities (Section 3.1, "Facility Effluent Monitoring"), and via contaminated ground-water seepage (Dirkes 1990, DOE 1992e, McCormack and Carlile 1984, Peterson 1992).

A special study was conducted in 1994 to investigate the difference in sediment grain size composition and total organic carbon content at routine Pacific Northwest National Laboratory monitoring sites (Blanton et al. 1995b). Physicochemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were collected above McNary Dam and from White Bluffs Slough. All other samples primarily consisted of sand-sized particles. Higher contaminant burdens were generally associated with sediments containing higher total organic carbon and finer grain-size distributions, which is consistent with other sediment investigations (Gibbs 1973, Karickhoff et al. 1978, Lambert 1967, Mudroch 1983, Nelson et al. 1966, Richardson and Epstein 1971, Sinex and Helz 1981, Suzuki et al. 1979, Tada and Suzuki 1982).

Collection and Analysis of Sediment Samples

Samples of Columbia River surface sediments (0-15 cm [0-6 in.]) were collected from six permanently-inundated and five periodically-inundated monitoring sites during 1995 (Figure 4.2.1, Table 4.2.2). Samples were collected upstream of Hanford facilities above Priest Rapids Dam (the nearest upstream impoundment) to provide background data from an area unaffected by Site operations. Samples were collected downstream of Hanford above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Note that any increases in contaminant concentrations found in sediment above McNary Dam relative to that found above Priest Rapids Dam do not necessarily reflect a Hanford source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns and factories in this area may also contribute to the contaminant load found in McNary Dam sediment.

In addition to sampling from Columbia River impoundments, sediment samples were also collected along the Hanford Reach of the Columbia River from areas in close proximity to contaminant discharges (e.g., riverbank springs), from slackwater areas where fine-grained material is known to deposit (e.g., the White Bluffs Slough, 100-F Slough, and Hanford Slough), and from areas commonly used by the public (e.g., the Richland shoreline).

Monitoring sites located at McNary and Priest Rapids Dams consisted of four stations spaced equidistant along a Columbia River transect. All other monitoring sites consisted of a single sampling location. Samples of permanently-inundated river sediment, herein referred to as river sediment, were collected using a Petite Ponar Grab sampler with a 235-cm^2 opening. Samples of periodically-inundated river sediment, herein referred to as riverbank spring sediment, were collected using a large plastic spoon, immediately following the collection of riverbank spring water samples. Sampling methods are discussed in detail in the *Environmental Monitoring Plan* (DOE 1994a). All sediment samples were analyzed for gamma emitters (see Appendix E), strontium-90, uranium-235, -238, and inductively coupled plasma (method) metals (DOE 1994a). River sediment samples were also analyzed for plutonium-238, plutonium-239,240, and lead. Sample analyses of Columbia River sediments were selected based on findings of previous Columbia River sediment investigations, reviews of past and present effluents discharged from Site facilities, and reviews of contaminant concentrations observed in near-shore groundwater monitoring wells.

Radiological Results for River Sediment Samples

Results of the radiological analyses on river sediment samples collected during 1995 are reported by Bisping (1996) and summarized in Appendix A, Table A.6. Radionuclides consistently detected in river sediment adjacent and downstream of Hanford during 1995 at concentrations greater than two times their total propagated analytical uncertainty included cobalt-60, strontium-90, cesium-137, europium-154, europium-155, uranium-235 and -238, and plutonium-239,240. The concentrations of all other measured radionuclides were less than two times their respective total propagated analytical uncertainties in over 50% of samples collected. Strontium-90 and plutonium-239,240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Uranium occurs naturally in the environment in addition to being present in Hanford effluents. Comparisons of contaminant concentrations between sediment sampling locations are made below. Due to the variation in the bioavailablity of contaminants in various sediments, no state or federal freshwater sediment criteria are currently available to assess the sediment quality of the Columbia River (EPA 1994).

Radionuclide concentrations reported in river sediment in 1995 were similar to those reported previously, with the exceptions of uranium-235 and uranium-238 (Appendix A, Table A.6). Uranium-235 and -238 concentrations were slightly higher at McNary and Priest Rapids Dams in 1995 than in recent years. No appreciable differences in isotopic uranium concentrations were noted between locations. Regional minimum, median, and maximum concentrations of select radionuclides measured in river sediment from 1990 through 1995 are presented in Figure 4.2.11. Regions include the sampling stations at Priest Rapids and McNary Dams as well as the Hanford Reach stations of the White Bluffs Slough, 100-F Area Slough, Hanford Slough, and the Richland Pumphouse. Strontium-90 is the only radionuclide to exhibit consistently higher regional median concentrations at McNary Dam from 1990 through 1995. The regional rank of all other radionuclide concentrations varied from year to year. The regional median concentrations of beryllium-7, strontium-90, and plutonium-239,240 were highest in McNary Dam sediment in 1995. The regional median concentration of cobalt-60 was highest along the Hanford Reach. No other radionuclides measured in 1995 exhibited appreciable differences in concentrations between locations.

Radiological Results for Riverbank Spring Sediment Samples

Riverbank spring sediment sampling was initiated in 1993 at the old Hanford Townsite and 300 Area. The 100-B Area, 100-K Area, and 100-F Area riverbank springs were added in 1995. Sediments at all other riverbank spring sampling locations consisted of predominantly large cobble and were unsuitable for sample collection.

Radiological results for riverbank spring sediment collected in 1995 are presented in Bisping (1996) and are summarized in Appendix A, Table A.6. The highest concentrations of measured radionuclides were generally detected in sediment collected from the old Hanford Townsite riverbank spring. Exceptions include uranium-235

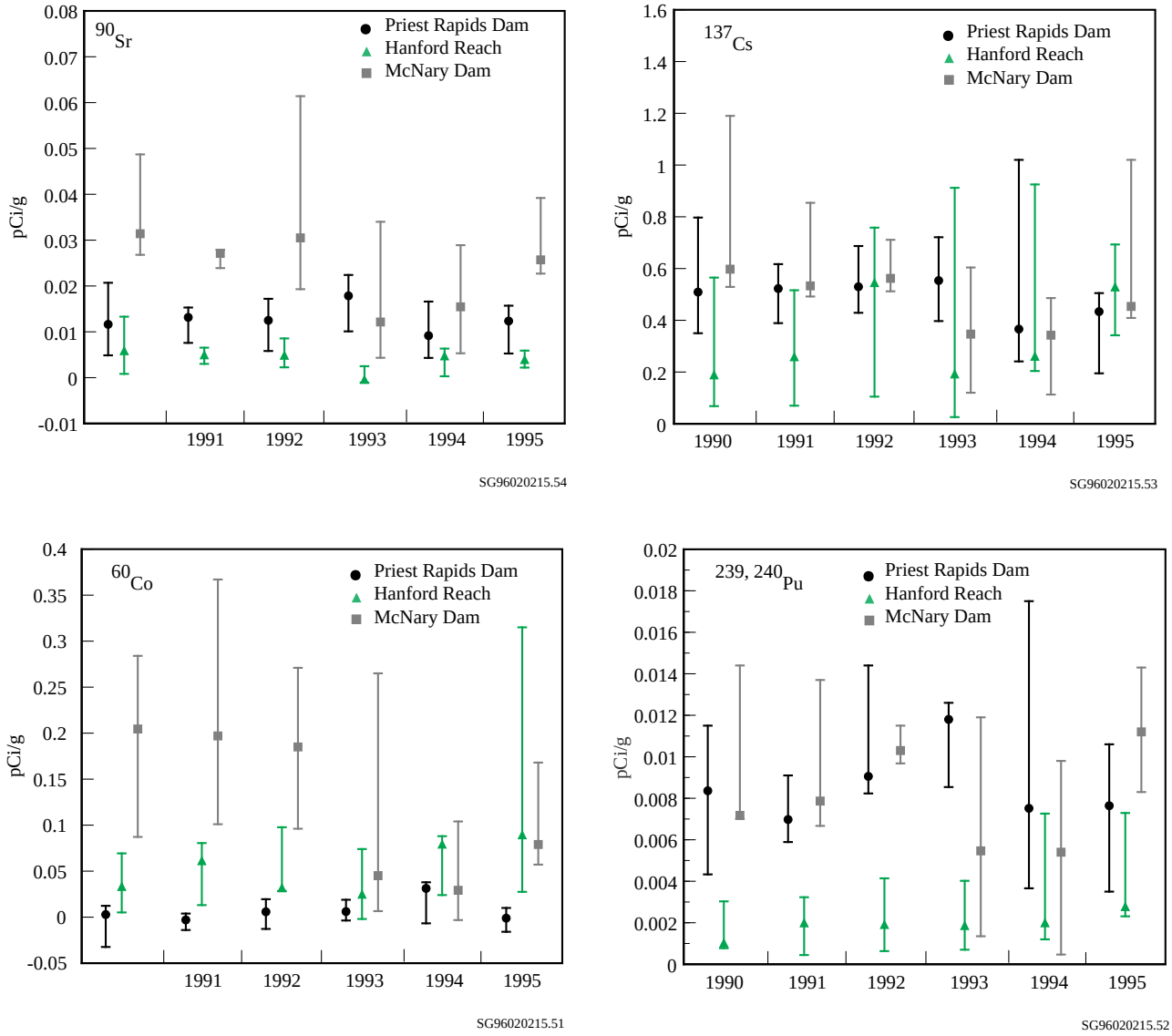

Figure 4.2.11. Minimum, Median, and Maximum Concentrations of Select Radionuclides Measured in Columbia River Sediments, 1990 Through 1995. As a result of figure scale, some minimum and maximum values are concealed by the point symbol.

and uranium-238, which were highest in sediment collected from the 300 Area riverbank spring, and europium-155, which was highest in sediment collected from the 100-K Area riverbank spring. The ranking of radionuclide concentrations in riverbank spring sediment in 1995 was generally consistent with that of riverbank spring water. Results for riverbank spring sediment collected from the old Hanford Townsite and 300 Area in 1995 were similar to those observed previously.

Radionuclide concentrations in riverbank spring sediment were similar to those observed in river sediment in 1995 with the exception of uranium, which was much higher in 300 Area riverbank spring sediment than elsewhere in the river. Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive waste sites known to have received uranium waste (Dresel et al. 1996).

Nonradiological Results for Columbia River Sediment Samples

Metal concentrations observed in Columbia River sediment in 1995 are reported by Bisping (1996) and are summarized in Appendix A, Table A.7. Levels of all measured metals were detected in all Columbia River sediment samples with the exceptions of silver, detected only in McNary Dam sediment, and antimony, detected mainly in riverbank spring sediment. Regional median concentrations of most metals were highest in McNary Dam sediments (Figure 4.2.12). The highest median concentration of chromium, however, was found in riverbank spring sediment; maximum concentrations of chromium occurred in the 100-K Area, 100-B Area, and 100-F Area riverbank springs. Maximum concentrations of antimony, calcium, cobalt, copper, iron, magnesium, manganese, nickel, sodium, tin, vanadium, and zinc were found in either Hanford Slough river sediment or old Hanford Townsite riverbank spring sediment.

Riverbank Springs Water

The Columbia River is the primary discharge area for the unconfined aquifer underlying the Hanford Site (Dresel et al. 1996). Ground water thus provides a means for transporting Hanford-associated contaminants, which have leached into ground water from past waste disposal practices, to the Columbia River (Dirkes 1990, DOE 1992e, McCormack and Carlile 1984, Peterson 1992).

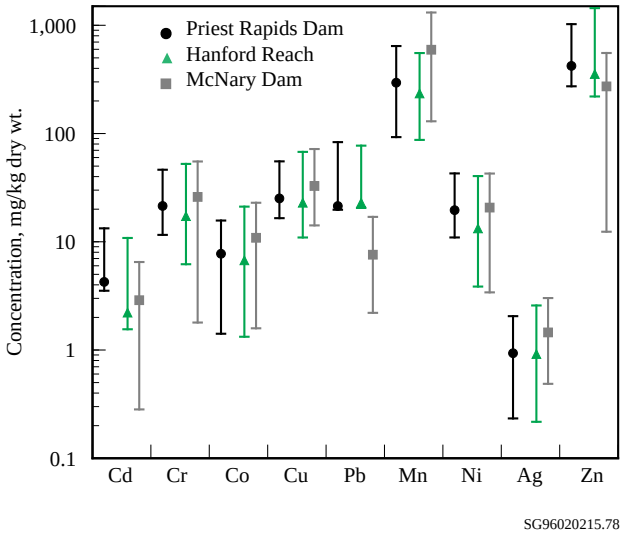

Figure 4.2.12. Minimum, Median, and Maximum Concentrations of Select Metals Measured in Columbia River Sediments, 1995

Contaminated ground water enters the Columbia River via surface and subsurface discharge. Discharge zones located above the water level of the river are identified in this report as riverbank springs. Routine monitoring of riverbank springs offers the opportunity to characterize the quality of ground water being discharged to the river and to assess the potential human and ecological risk associated with the spring water.

The seepage of ground water into the Columbia River has been known to occur for many years. Riverbank springs were documented along the Hanford Reach long before Hanford operations began during World War II (Jenkins 1922). McCormack and Carlisle (1984) walked the 41-mile stretch of shoreline of the Hanford Reach of the Columbia River in 1983 and identified 115 springs. They reported that the predominant areas of ground-water discharge at that time were in the vicinity of the 100-N Area, the old Hanford Townsite, and the 300 Area. The predominance of the 100-N Area may no longer be valid due to declining water-table elevations in response to the decrease in liquid-waste discharges from Hanford operations to the ground. In recent years, it has become increasingly difficult to locate springs in the 100-N Area.

The presence of springs varies with river stage. Dresel et al. (1996) reported that ground-water levels in the 100 and 300 Areas are heavily influenced by river-stage fluctuations. Water levels in the Columbia River fluctuate greatly on annual and even daily cycles and are controlled by the operation of Priest Rapids Dam, upstream

of the Site. Water flows into the aquifer (as bank storage) as the river stage rises, and flows in the opposite direction as the river stage falls. Following an extended period of low river discharge, ground-water discharge zones located above the water level of the river may cease to exist once the level of the ground water comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage. Bank storage of river water also effects the contaminant concentration of the springs. When the river stage is high, river water flowing into the aquifer overlays and/or mixes with ground water. Spring discharge immediately following a river stage decline generally consists of river water or a river-ground-water mix. The percent contribution of ground water to spring discharge is believed to increase over time.

Due to the effect of bank storage on ground-water discharge and contaminant concentration, it is difficult to estimate the volume of radiologically and chemically contaminated ground water discharged to the Columbia River within the Hanford Reach. An unpublished estimate of total ground-water discharge from the upstream end of the 100 Areas to south of the 300 Area is approximately 66,500 m^3/day (2,350,000 ft^3/day).[(a)] This amount is 0.02% of the long-term average annual flow rate of the Columbia River, which illustrates the tremendous dilution potential offered by the river. Note that not all of the ground water discharged to the river contains contaminants originating from Hanford Site operations. Riverbank spring studies conducted in 1983 (McCormack and Carlisle 1984) and in 1988 (Dirkes 1990) noted that spring discharges had a localized effect on river contaminant concentrations. But both studies reported that the volume of ground water entering the river at these locations was very small relative to the flow of the Columbia River and that the impact of ground-water discharges to the river was minimal.

Collection and Analysis of Riverbank Spring Water Samples

Routine monitoring of select riverbank springs was initiated in 1988 at the 100-N Area, old Hanford Townsite, and 300 Area. The monitoring plan was expanded in 1993 to include the 100-B, 100-K, 100-D, and 100-H Areas. The 100-F Area spring was added in 1994. The locations of all riverbank springs sampled in 1995 are identified in Figure 4.2.1. Sample collection methods are described in the *Environmental Monitoring Plan* (DOE 1994a).

Sampling is conducted once or twice annually during low river flow (August through September). The specific conductivities of samples collected from 100-N and 100-D Area springs in August 1995 were similar to that of the Columbia River water. This indicated that the samples were primarily composed of bank storage river water. This conclusion is supported by the unusually low contaminant concentrations observed in the samples (see subsequent discussion). A second riverbank spring sample from 100-D Area was collected in September. Further attempts to locate and sample a 100-N Area spring were unsuccessful.

Sample analyses of Columbia Riverbank springs water are selected based on findings of previous riverbank springs investigations, reviews of contaminant concentrations observed in nearby ground-water monitoring wells, and results of preliminary risk assessments. At a minimum, riverbank springs samples collected during 1995 were analyzed for gamma-emitting radionuclides, strontium-90, technetium-99, total alpha, total beta, tritium, and uranium-234, -235, and -238. Iodine-129 analysis was included for locations where iodine-129 was known to exist in the ground water as a result of past Hanford operations. Riverbank springs were also analyzed for various nonradiological contaminants including metals, anions, and volatile organic compounds. All analyses were conducted on unfiltered samples.

Results for Riverbank Springs Water

Hanford-origin contaminants continued to be detected in riverbank spring water entering the Columbia River along the Hanford Site during 1995. The locations and extent of contaminated discharges were consistent with recent ground-water surveys. Tritium, strontium-90, technetium-99, uranium-234, -235, and -238, cadmium, chloroform, chromium, copper, nitrate, trichloroethylene (TCE), and zinc were found to be entering the river along the 100 Area shoreline. Tritium, technetium-99, iodine-129, uranium-234, -235, and -238, chromium, nitrate, and zinc entered the river along the portion of shoreline extending from the old Hanford Townsite to below the 300 Area. Strontium-90 was discharged to

(a) Stuart Luttrell, Ground-Water Surveillance Project Manager, Pacific Northwest National Laboratory, Richland, Washington, January 1995.

the river along the 300 Area shoreline in addition to the other contaminants. The contaminant concentrations in spring water are typically lower than those found in near-shore ground-water wells due to bank storage effects.

The results of radiological and chemical analyses conducted on riverbank springs samples in 1995 are documented by Bisping (1996). Radiological results reported in 1995 are summarized in Appendix A, Table A.8, and compared to those reported in 1990 through 1994. In the following discussion, radiological and nonradiological results are addressed separately. Contaminant concentration trends are illustrated for locations for which more than 3 years of data are available.

Radiological Results for Riverbank Springs Water Samples

All radiological contaminant concentrations measured in riverbank springs in 1995 were less than DOE Derived Concentration Guides (Appendix C, Table C.5). However, strontium-90 in the 100-H Area and tritium in the 100-B Area and along the old Hanford Townsite exceeded the Washington State ambient surface water quality criteria levels (Appendix C, Table C.1). There are currently no ambient surface water quality criteria levels directly applicable to uranium. However, total uranium (i.e., the sum of uranium-234, -235, and -238 concentrations) exceeded the Site-specific proposed EPA Drinking Water Standard in the 300 Area (Appendix C, Table C.2). All other radionuclide concentrations were less than ambient surface water quality criteria levels. The range of concentrations of select radionuclides measured in riverbank spring water from 1990 through 1995 is presented in Table 4.2.3.

Tritium concentrations vary widely with location. The highest concentrations are normally detected in the old Hanford Townsite riverbank spring, followed by the 100-B and 100-K Area springs. In 1995, however, the highest concentration of tritium was found in the 100-B Area spring. The tritium concentration of the old Hanford Townsite spring was lower than normally observed, probably as a result of bank storage (see subsequent discussion). The tritium concentration in the 100-B Area spring was slightly higher than the concentration previously found and was higher than that recently reported in 100-B Area ground water (Dresel et al. 1996).

Technetium-99 was detected in the 100-B, 100-N, 100-H, old Hanford Townsite, and 300 Area springs in 1995. The highest concentrations were found in the 100-H Area, which is consistent with past results and with recent ground-water reports. Uranium was found in all riverbank spring samples in 1995 but the highest total uranium and total alpha concentrations were found in the 300 Area spring, downgradient from the 316-5 Process Trenches. Iodine-129 was detected in the old Hanford Townsite and 300 Area riverbank springs; the highest concentrations were found in the vicinity of the old Hanford Townsite.

Strontium-90 was detected in the 100-D, 100-H, and 300 Area springs in 1995; the highest levels were found in the 100-H Area. Beta activity paralleled that of strontium-90. Results are consistent with those in 1993 and 1994. Before 1993, however, the highest levels of strontium-90 and total beta were found in the 100-N Area. These high concentrations were measured in samples collected from near-shore ground-water wells and not from riverbank springs.

The Near-Facility Environmental Monitoring Program has historically sampled the 100-N Area riverbank seepage from the 199-N-8T monitoring well, which is located close to the river (see Figure 3.2.4). This well was also sampled annually by Pacific Northwest National Laboratory in 1990 and 1991. In 1992, the Pacific Northwest National Laboratory sample was collected from well 199-N-46 (cassion), which is located slightly inland from well 199-N-8T. In 1993, 1994, and 1995, Pacific Northwest National Laboratory 100-N Area spring samples were collected from actual ground-water seepage entering the river along the shoreline. Sampling in this manner is consistent with the sampling protocol at other riverbank spring locations and avoids duplicating efforts of the Westinghouse Hanford Company's Near-Facility Environmental Monitoring Program.

In 1993, 1994, and 1995, there was no visible shoreline seepage present directly adjacent to well 199-N-8T during sampling. The 100-N Area spring samples were instead collected from the nearest visible downstream riverbank spring. As a result of the relative proximity of the riverbank springs and monitoring wells to the contaminant plumes emanating from the 100-N Area, and as a result of bank-storage effects, some contaminant concentrations measured in the spring water were distinctly different from those previously measured in either of the two wells (Table 4.2.4). The concentrations of strontium-90 and total beta were much lower in riverbank spring water than in near-shore ground water. Tritium concentrations in riverbank spring water were similar to those found in well 199-N-8T and slightly higher than those found in

Table 4.2.3. Range of Radiological Data for Columbia Riverbank Springs, 1990-1995

	Ambient Surface Water Quality Criteria Level (pCi/L)	Concentration, pCi/L							
		100-B Area	100-K Area	100-N Area	100-D Area	100-H Area	100-F Area	Hanford Townsite	300 Area
No. of Samples		5	3	6	5	5	2	7	7
Total alpha	15[(a)]	1.14 - 3.54	ND - 1.63	ND	0.93 - 2.90	3.29 - 4.59	2.61 - 3.73	ND - 4.88	12.7 - 110
Total beta	50	7.69 - 38.1	1.84 - 3.60	ND - 24,100	2.14 - 20.8	39.4 - 69.1	1.74 - 2.04	ND - 33.2	3.31 - 29.3
Tritium	20,000	11,000 - 22,500	17,800 - 19,700	4,870 - 30,900	ND - 12,500	691 - 1,190	623 - 1,620	6,340 - 173,000	1,260 - 11,600
^{90}Sr	8	ND[(b)]	ND	ND - 10,900	ND - 9.41	12.4 - 25.2	ND - 0.0986	ND (5)	ND - 0.198 (5)
^{99}Tc	900	8.40 - 25.3	ND - 0.805	ND - 2.44	ND	43.7 - 136	ND (1)[(c)]	2.04 - 131	ND - 13.5 (6)
^{129}I	1							ND - 0.224 (3)	0.00187 - 0.00439 (2)
Total uranium		1.57 - 3.16	1.27 - 2.28	0.239 - 2.47	0.283 - 1.92	5.22 - 8.35	3.37 - 4.62	2.32 - 4.29 (5)	24.2 - 129

(a) Ambient surface water quality criteria level for total alpha excludes uranium.
(b) ND indicates result was less than 2 total propagated analytical uncertainty.
(c) Number in parentheses indicates number of samples used to calculate the range, if different from above.

Table 4.2.4. Selected Radionuclide Concentrations in 100-N Riverbank Spring Water During the Years 1990 Through 1995

Year	Concentration, pCi/L[a]		
	^{3}H	Total beta	^{90}Sr
1990[b]	38,500 ± 2,950	8,520 ± 603	3,990 ± 734
1991[b]	11,300 ± 1,040	7,140 ± 574	5,110 ± 1,000
1992[c]	4,870 ± 501	24,100 ± 1,730	10,900 ± 2,020
1993[d]			
Min	28,500 ± 2,220	2.41 ± 3.17	-0.0104 ± 0.221
Max	28,900 ± 2,260	4.50 ± 3.32	0.0204 ± 0.256
1994[d]	30,900 ± 2,380	8.79 ± 2.26	0.129 ± 0.107
1995[d]	12,000 ± 969	1.48 ± 1.49	0.079 ± 0.104

(a) Concentrations are ±2 total propagated analytical uncertainty.
(b) Samples collected from well 199-N-8T (see Figure 3.2.4).
(c) Sample collected from well 199-N-46 (see Figure 3.2.4).
(d) Sample collected from shoreline spring downstream of well 199-N-8T.

well 199-N-46. Tritium, technetium-99, and total uranium were the only measured contaminants with concentrations that were greater than two times their total propagated analytical uncertainty in 1995 (Table 4.2.3). The tritium and technetium-99 concentrations were 60% and 0.1% of the ambient surface water quality criteria levels, respectively. The total uranium concentration was 2% of the Site-specific proposed EPA Drinking Water Standard.

Concentrations of selected radionuclides in riverbank springs near the old Hanford Townsite for 1990 through 1995 are provided in Figure 4.2.13. Total beta and technetium-99 concentrations in 1995 were similar to those observed in 1994 and slightly lower than those observed previously. The tritium concentration was lower than normal but similar to that observed in one sample collected in 1994. The lower contaminant concentrations in 1994 and 1995 may result from dilution of groundwater discharge by river water that entered the riverbank during higher flows. The specific conductivities of those samples that exhibited unusually low contaminant concentrations were between those normally found in river water and those found previously in the old Hanford Townsite riverbank spring water. With the exception of total uranium, all other measured contaminant concentrations in 1995 were rarely greater than two times their associated total propagated analytical uncertainty. Total uranium concentrations were less than 17% of the Site-specific proposed EPA Drinking Water Standard. The iodine-129 concentration measured in the old Hanford Townsite riverbank spring (0.0638 ± 0.0057 pCi/L) was 6% of the ambient surface water quality standard.

Figure 4.2.14 depicts the concentrations of selected radionuclides in the 300 Area riverbank spring from 1990 through 1995. Results in 1995 were similar to those observed previously. Elevated contaminant concentrations during 1992 are believed to have resulted from coordinated efforts with Priest Rapids Dam to control the water level of the river during the 1992 riverbank spring sampling activities. Maintaining a low river water level during sampling in 1992 maximized the contribution of ground water in the springs, and minimized the bank storage effect, to provide samples that reflected limiting water quality conditions. The elevated tritium concentrations measured in the 300 Area riverbank spring during the past 5 years reflects the expansion of the contaminated ground-water plume emanating from the 200 Areas (Dresel et al. 1996). Technetium-99 and iodine-129 are also contained in the 200 Area contaminated groundwater plume. Tritium, technetium-99, and iodine-129 concentrations in 300 Area riverbank spring water in 1995 were 58%, 2%, and 0.5% of their respective ambient surface water quality criteria levels. The highest total uranium concentrations in riverbank sping water from 1990 through 1995 were found in the 300 Area riverbank springs. Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive waste sites. Total alpha and total beta concentrations in the 300 Area riverbank spring water from 1990 through 1995 parallel that of uranium and are likely associated with its presence. With the exception of strontium-90, the concentrations of all other measured contaminants in the 300 Area spring in 1995 were generally less than two times their associated total propagated analytical uncertainty. The concentration of strontium-90 was 3% of the ambient surface water quality criteria level. Potential sources of strontium-90 in 300 Area ground water are the research reactor and research buildings. Low levels of strontium-90 have been detected in 300 Area ground water (Dresel et al. 1996).

Nonradiological Results for Riverbank Springs Water Samples

The range of concentrations of selected chemical compounds measured in riverbank spring water in 1993

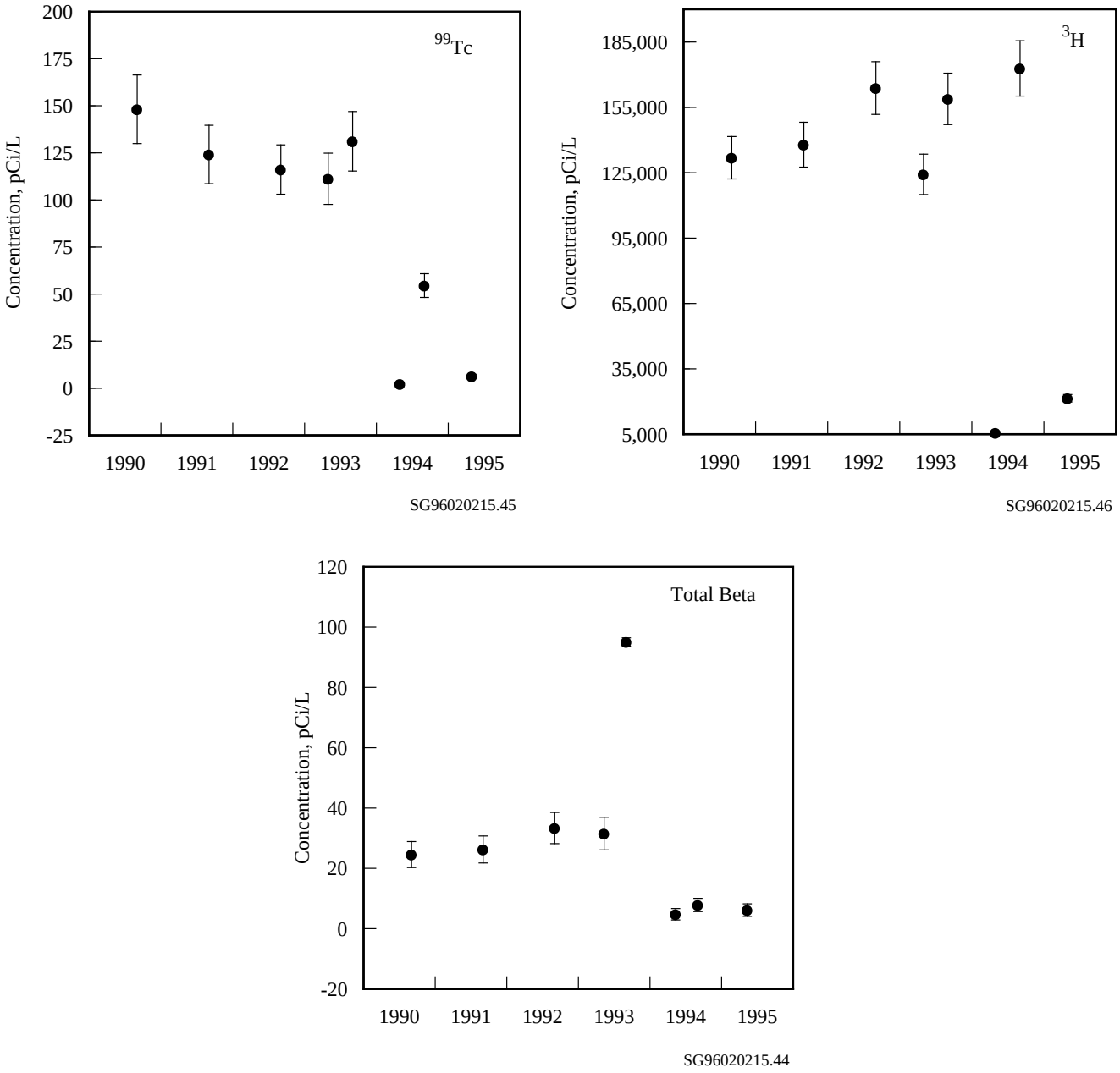

Figure 4.2.13. Concentrations (±2 total propagated analytical uncertainty) of Constituents of Interest in the Riverbank Spring Near the Old Hanford Townsite, 1990 Through 1995. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

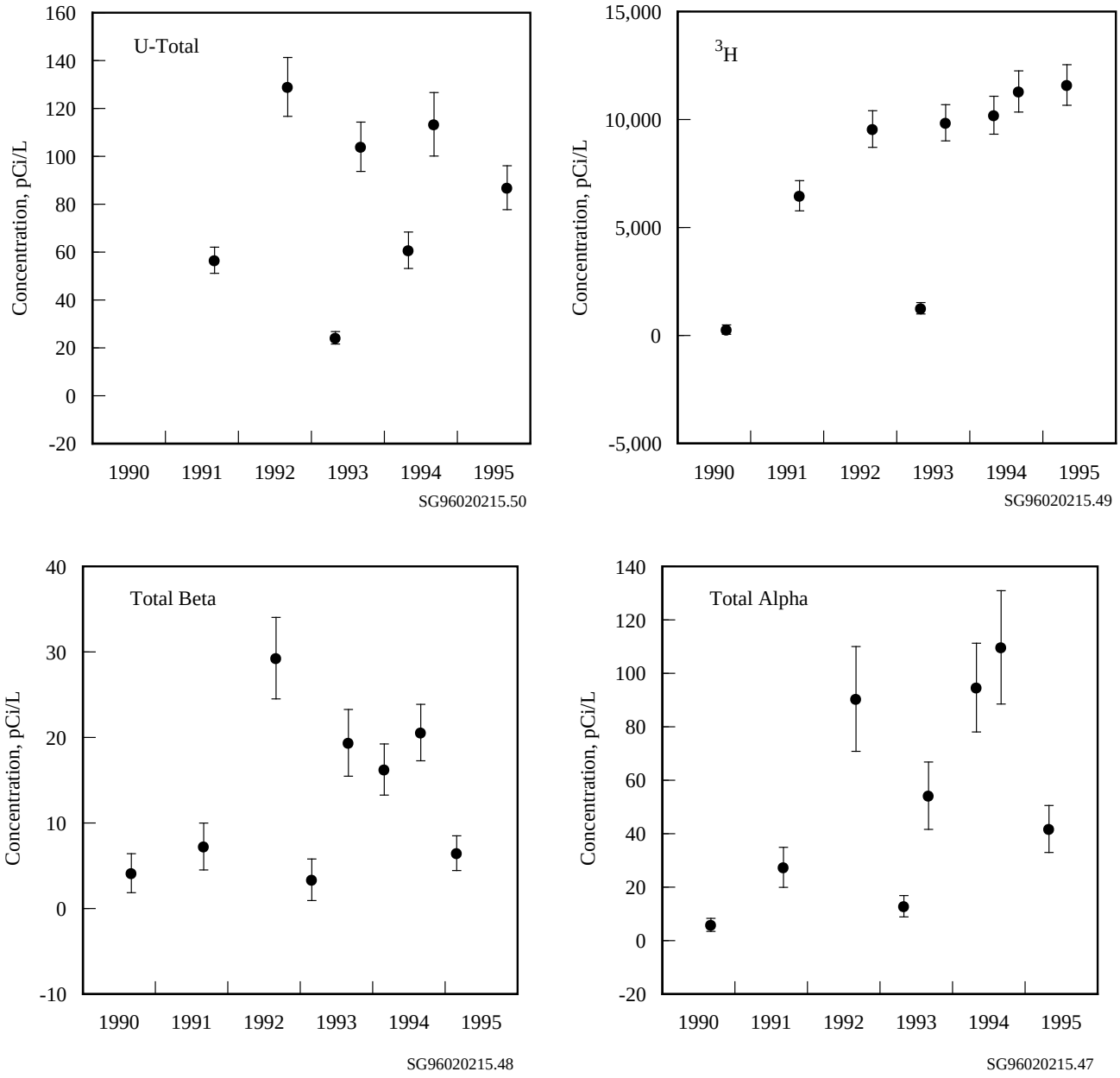

Figure 4.2.14. Concentrations (±2 total propagated analytical uncertainty) of Constituents of Interest in the 300 Area Riverbank Spring, 1990 Through 1995. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 4.2.5. Concentration Ranges of Select Nonradiological Compounds in Columbia Riverbank Springs, 1993-1995

	Ambient Surface Water Quality Criteria Level (µg/L)	Concentration, µg/L							
		100-B Area	100-K Area	100-N Area	100-D Area	100-H Area	100-F Area	Hanford Townsite	300 Area
No. of Samples		3	1	2	4	3	2	3	2
Metals									
Aluminum		34-610	4,800	ND[a]-9,400	66-180	27-88	41-1,700	67-750	140-960
Barium		55-59	120	32-140	34-80	27-48	41-58	43-54	95-96
Cadmium	[b]	ND	2	ND	ND	ND	ND-1.1	ND	ND
Chromium	[b]	21-25	66	ND-45	ND-400	18-55	6-37	ND	ND-4.4
Copper	[b]	ND	37	ND-30	ND-6.4	ND-4.7	ND-3.9	ND-5.4	ND-3.5
Iron		25-860	9,300	60-12,000	93-250	52-180	18-2,500	100-1,200	190-1,200
Manganese		1.9-22	330	3.2-680	6.6-13	7.6-11	3.1-39	7.1-82	5.8-30
Nickel	[b]	ND	ND	ND-25	ND-26	ND	ND-20	ND-22	ND
Vanadium		ND-11	33	6.6-42	ND-5.3	ND-3.6	ND-9.3	ND-19	ND-4
Zinc	[b]	ND-45	410	3.8-460	7.3-11	7-15	7.3-62	5.4-32	9.6-30
Anions									
Nitrate		7,600-7,900	15,000	3,800-15,000	1,000-46,000	27,000-47,000	20,000-30,000	5,000-40,000	22,000-23,000
Volatile Organics									
Chloroform	5.7	ND-0.44 (4)[c]	ND-0.79 (3)	0.75-3 (4)	ND-4.1 (5)	3.7-14 (4)	ND	ND (4)	ND
Methylene chloride	4.7	ND-0.49 (7)	ND (5)	ND-1.3 (7)	ND-1.2 (8)	ND-1.2 (7)	ND-1.2 (3)	ND-0.52 (7)	ND (3)
Tetrachloroethylene	0.8	ND (4)	ND (3)	ND-1.4 (4)	ND (5)	ND (4)	ND	ND (4)	ND
Trichloroethylene	2.7	0.53-1.0 (4)	7.4-9.5 (3)	ND (4)	ND (5)	ND (4)	ND	ND (4)	ND

(a) ND indicates result was less than the minimum detection level.
(b) Ambient surface water quality criteria level is hardness-dependent (see Appendix C, Table C.3).
(c) Number in parentheses indicates number of samples used to calculate the range, if different from above.

through 1995 are presented in Table 4.2.5. The low concentrations of all compounds reported in the 100-N and 100-D Area springs were measured in August 1995 samples collected from those locations and are more representative of Columbia River water than of local ground water conditions. With the exceptions of August 1995 sample results for 100-N and 100-D Area springs, riverbank spring nonradiological results in 1995 were similar to those reported previously. Metal concentrations are typically highest in the 100-K and 100-N Area springs with the exception of the chromium concentration, which is highest in the 100-D Area spring. Nitrate concentrations are highest in the 100-D, 100-H, and old Hanford Townsite Area springs. Trichloroethylene is highest in the 100-K Area spring. Hanford ground-water monitoring results for 1995 indicate similar relationships between nonradiological contaminant concentrations in shoreline areas (Dresel et al. 1996).

Washington State ambient surface water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total hardness-dependent (Appendix C, Table C.3). Criteria for Columbia Riverbank spring water were calculated assuming the total hardness was attributable only to calcium and magnesium. Other multivalent cations typically comprise a small fraction of total hardness. Considering only calcium and magnesium in the calucu-lations provided the most limiting surface water quality criteria.

With the exception of trichloroethylene, the concentrations of all anion and volatile organic compounds measured in riverbank spring water collected from the Hanford shoreline in 1995 were below Washington State ambient surface water quality criteria levels. The concentration of trichloroethylene exceeded the EPA standard to protect human health for the consumption of water and organisms in the 100-K Area riverbank spring. Riverbank spring sampling protocol does not lend itself to a direct comparison of most metal concentrations measured in riverbank springs to ambient surface water acute and chronic toxicity levels. The standards are, instead, used as a point of reference. The ambient surface water acute and chronic toxicity levels of arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc are 1-hour and 4-day average concentrations, respectively, not to be exceeded more than once every 3 years on the average (Washington Administrative Code 173-201A-040). Riverbank spring samples are grab samples. Metal concentrations measured in riverbank springs located on the Hanford shoreline in 1995 were below Washington State ambient surface water acute toxicity levels, with the exceptions of copper and zinc in the 100-K Area spring. The chronic toxicity level of cadmium was also exceeded in the 100-K Area spring. The minimum detectable concentration of antimony exceeded EPA standards to protect human health for the consumption of water and organisms in all springs. The minimum detectable concentrations of cadmium and silver exceeded their chronic and acute toxicity standards, respectively, in the August 1995 samples collected from 100-N and 100-D Area springs.

Onsite Pond Water

Three onsite ponds (see Figure 4.2.1) located near operational areas were sampled periodically during 1995. The B Pond, located near the 200-East Area, was excavated in the mid-1950s and expanded in the 1980s for disposal of process cooling water and other liquid wastes that occasionally contained low levels of radionuclides. The Fast Flux Test Facility Pond, located near the 400 Area, was excavated in 1978 for the disposal of cooling and sanitary water from various facilities in the 400 Area. West Lake, the only naturally occurring pond onsite, is located north of the 200-East Area (Gephardt et al. 1976). West Lake has not received direct effluent discharges from Site facilities; rather, its existence is caused by the intersection of the elevated water table with the land surface in the topographically low area south of Gable Mountain (and north of the 200-East Area). The artificially elevated water table occurs under much of the Hanford Site and reflects the artificial recharge from Hanford Site operations.

The Site Operations and Engineering contractor is responsible for monitoring effluents discharged to the ponds and for operational surveillance of the ponds. Although the ponds were inaccessible to the public and did not constitute a direct offsite environmental impact during 1995, they were accessible to migratory waterfowl, creating a potential biological pathway for the dispersion of contaminants (see Section 4.5, “Wildlife Surveillance”). Periodic sampling of the ponds also provided an independent check on effluent control and monitoring systems.

Collection and Analysis of Pond Water Samples

In 1995, grab samples were collected quarterly from B Pond, the Fast Flux Test Facility Pond, and West Lake. Unfiltered aliquots of all samples were analyzed for total

alpha and total beta activities, gamma-emitting radionuclides, and tritium. Samples from B Pond were also analyzed for strontium-90 and technetium-99. West Lake samples were also analyzed for strontium-90, technetium-99, and uranium-234, -235, and -238. Constituents were chosen for analysis based on their known presence in local ground water and in effluents discharged to the ponds and their potential to contribute to the overall radiation dose delivered to the public.

Radiological Results for Onsite Pond Water Samples

Analytical results from pond samples collected during 1995 are listed by Bisping (1996). With the exceptions of uranium-234 and -238 in the October sample of West Lake, radionuclide concentrations in onsite pond water were less than DOE Derived Concentration Guides (Appendix C, Table C.5). Average annual total beta concentrations exceeded the ambient surface water quality criteria level in West Lake. The average concentration of all other radionuclides was less than ambient surface water quality criteria levels (Appendix C, Table C.1).

Annual concentrations of selected radionuclides in B Pond for the years 1990 through 1995 are shown in Figure 4.2.15. B Pond comprises a series of four ponds: 216-B-3, -3A, -3B, and -3C (Figure 4.8.11). Before October 1994, B Pond samples were collected from 216-B-3. However, 216-B-3 and -3A Ponds were decommissioned in 1994, and 216-B-3B Pond was never active, although it did receive an accidental discharge one time. B Pond samples are currently collected from 216-B-3C. Contaminant concentrations found in samples collected from 216-B-3C Pond in 1995 are similar to those found previously in 216-B-3 Pond. Average total alpha, total beta, tritium, strontium-90, and cesium-137 concentrations in 1995 were 2%, 4%, 0.5%, 1%, and 1% of ambient surface water quality criteria levels, respectively. All other measured radionuclides were detected at concentrations greater than two times their total propagated analytical uncertainty in less than 25% of samples collected.

Figure 4.2.16 shows the annual total beta and tritium concentrations in Fast Flux Test Facility Pond from 1990 through 1995. Median concentrations of both constituents have remained stable in recent years. However, the tritium concentration in the July sample was 16,400 pCi/L, which is much higher than that observed previously. June and July samples of Fast Flux Test Facility drinking water also contained unusually high levels of tritium, comparable to those found in Fast Flux Test Facility Pond (see Section 4.3, "Hanford Site Drinking Water Surveillance"). During this time, backup water supply well 499-S0-7 was in use. Tritium levels in well 499-S0-7 are typically above 20,000 pCi/L, reflective of those observed in the local unconfined aquifer. The use of backup water supply well 499-S0-7 is most likely responsible for the high levels of tritium observed in Fast Flux Test Facility Pond in July as the primary source of water to Fast Flux Test Facility Pond is 400 Area sanitary water. Average total beta and tritium concentrations in Fast Flux Test Facility Pond water during 1995 were 28% and 42% of their respective ambient surface water quality criteria levels. The concentrations of all other measured contaminants in Fast Flux Test Facility Pond water were greater than two times their respective total propagated analytical uncertainties in less than 25% of samples collected.

The annual concentrations of selected radionuclides from 1990 through 1995 in West Lake are shown in Figure 4.2.17. Note that the peak total uranium concentration reported in 1995 (2,662 pCi/L) was calculated by summing uranium-234 and -238 concentrations only. The concentration of uranium-235 in this sample was not reported by the lab. Radionuclide concentrations in West Lake during 1995 were similar to those observed in the past. Total alpha and total beta concentrations in West Lake continued to be higher than the alpha and beta levels found in the other onsite ponds. These elevated levels are believed to result from high concentrations of naturally occurring uranium (Poston et al. 1991, Speer et al. 1976). Annual median total uranium concentrations have remained stable over the last 6 years. The range in concentration, however, has shown a dramatic increase. Both the minimum and maximum annual total uranium concentrations have risen in recent years; the highest concentration occurred in summer and fall when the water level in the pond was low. It is believed that relatively large concentrations of suspended sediment in the samples is causing the elevated results. Declines in ground-water levels in the 200 Areas have been recorded since the decommissioning of U Pond in 1984 and the shutdown of production facilities (Dresel et al. 1995). As a result, the water level in West Lake has dropped. Low water levels increase the likelihood of collecting samples that contain newly suspended sediment disturbed during the sampling process. Similar total uranium concentrations were reported by Poston et al. (1991) for West Lake samples that contained high concentrations of suspended sediment. Average concentrations of tritium, strontium-90, and technetium-99 in West Lake in 1995 were 1%, 5%, and 2%, respectively, of ambient surface water quality criteria levels and were

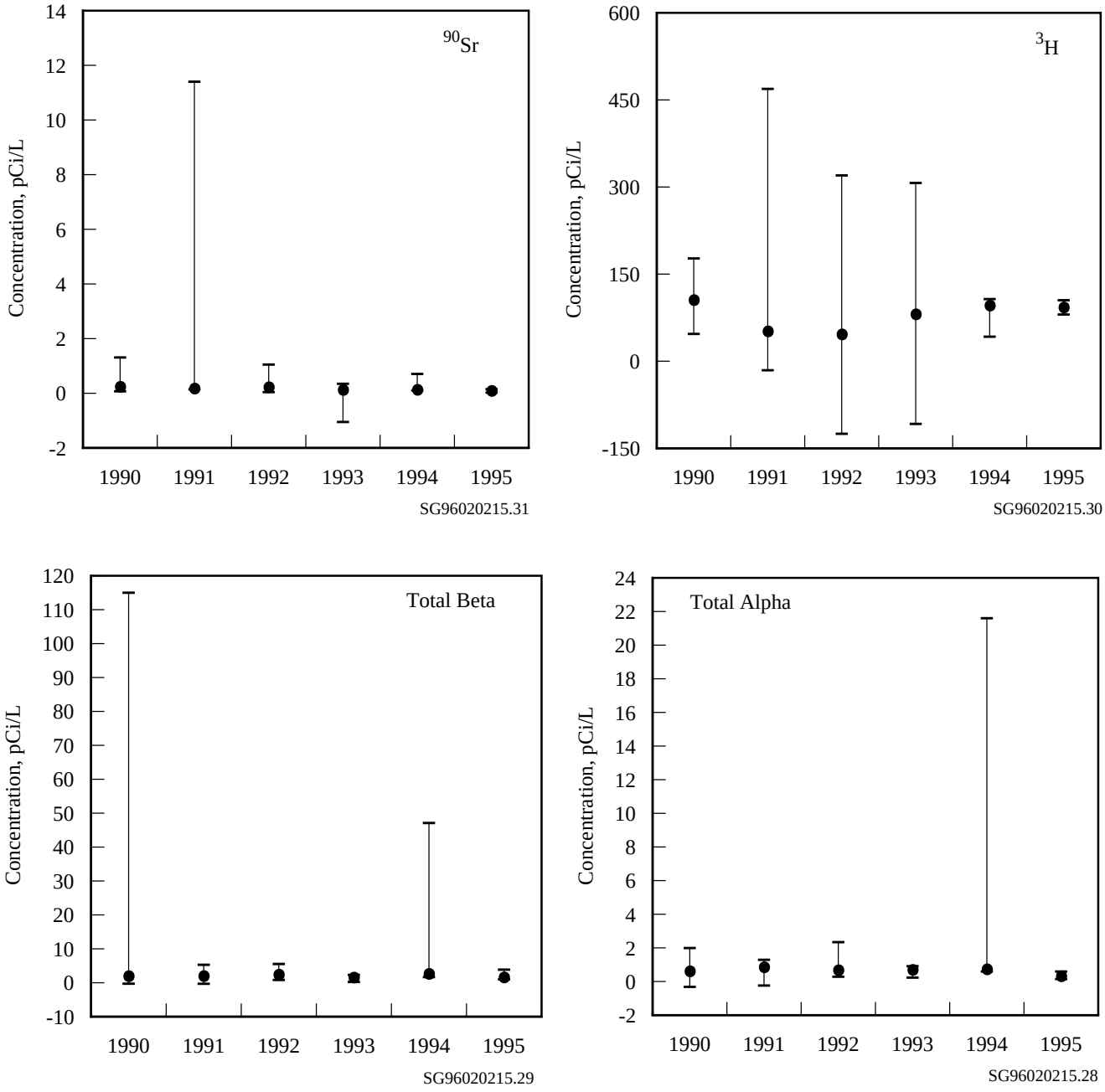

Figure 4.2.15. Minimum, Median, and Maximum Concentrations of Select Radionuclides in B Pond, 1990 Through 1995. As a result of figure scale, some maximum and minimum values are concealed by the point symbol.

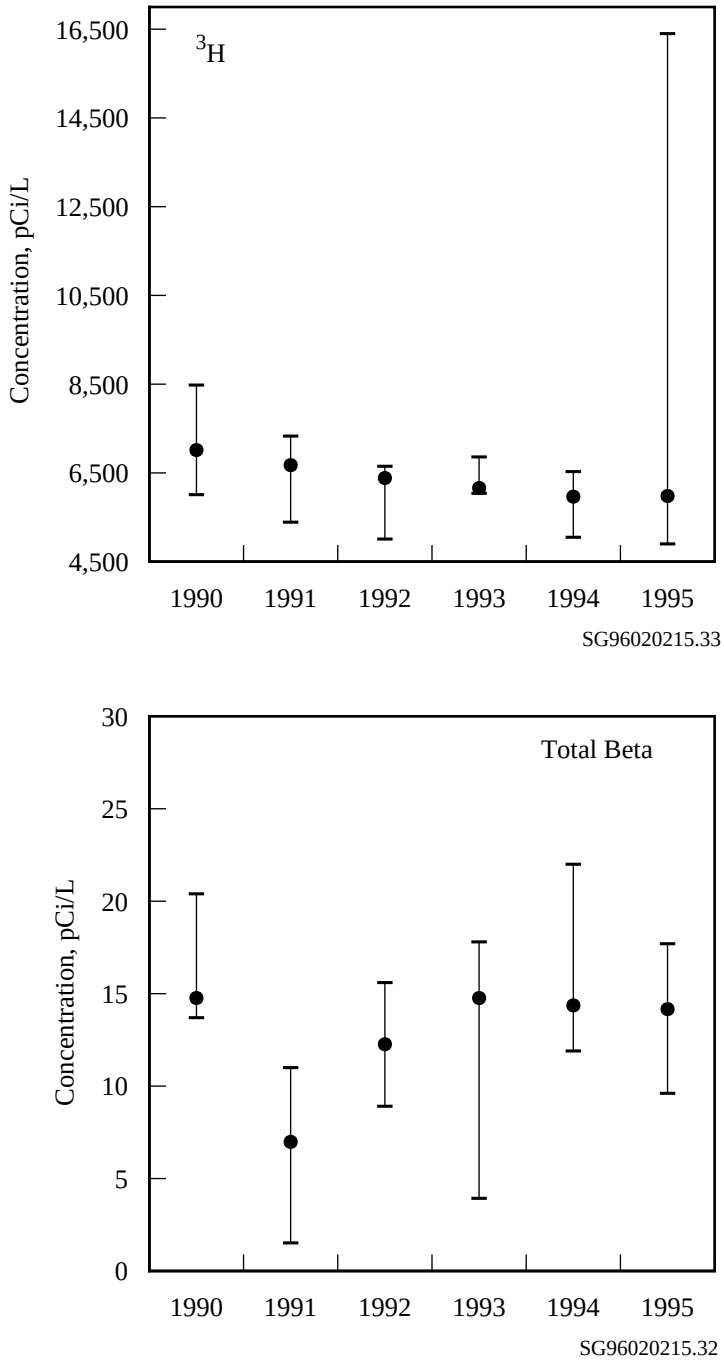

Figure 4.2.16. Minimum, Median, and Maximum Total Beta and Tritium Concentrations in the Fast Flux Test Facility Pond, 1990 Through 1995. As a result of figure scale, some maximum and minimum values are concealed by the point symbol.

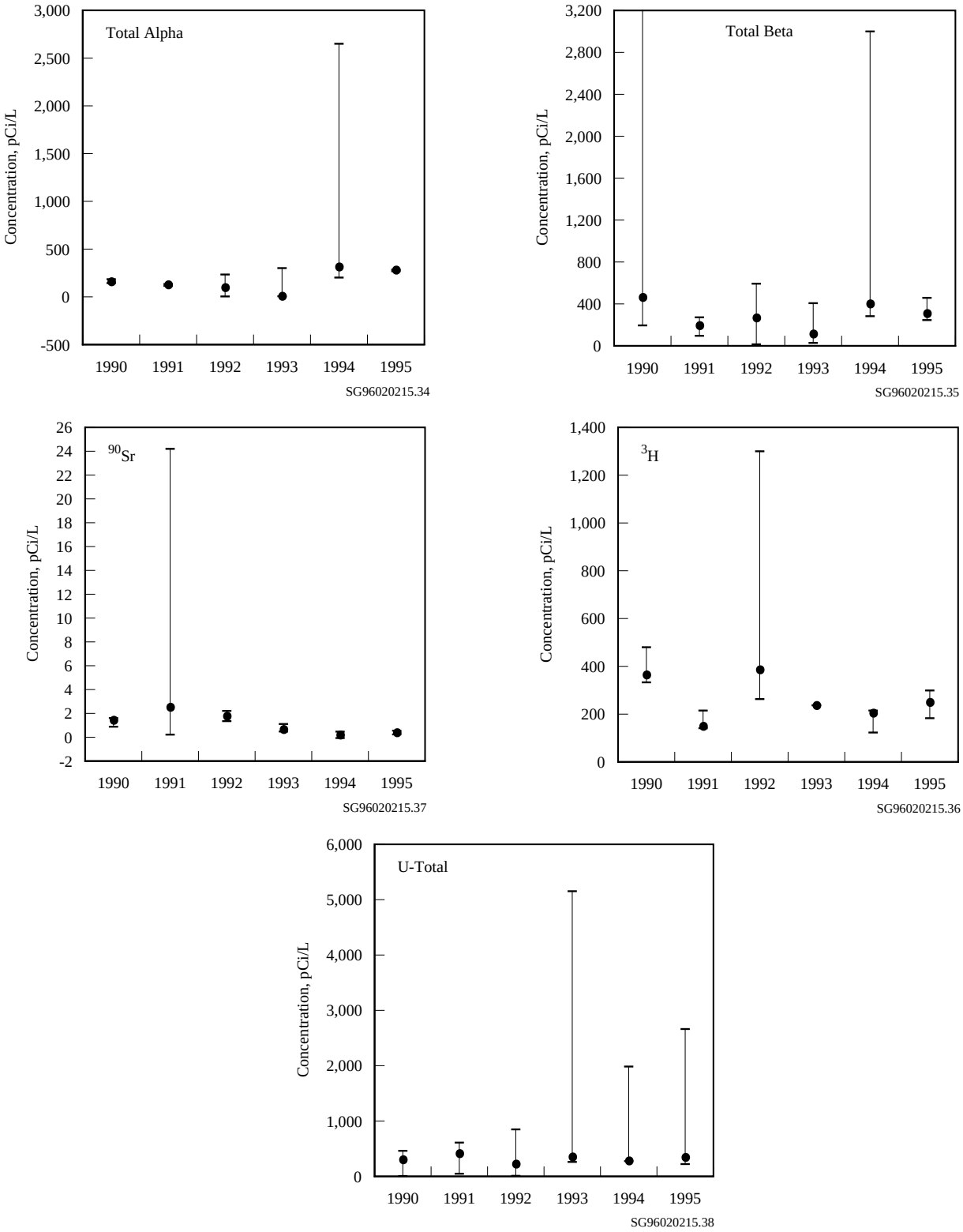

Figure 4.2.17. Minimum, Median, and Maximum Concentrations of Select Radionuclides in West Lake, 1990 Through 1995. As a result of figure scale, some maximum and minimum values are concealed by the point symbol. The maximum total beta concentration in 1990 was 271,000 pCi/L.

reflective of local ground-water concentrations. The concentrations of all other measured radionuclides were rarely higher than two times their associated total propagated analytical uncertainties.

Offsite Water

During 1995, water samples were collected from five water supplies that utilized ground water directly east of and across the Columbia River from the Hanford Site. Water samples were also collected from an irrigation canal downstream from Hanford that obtains water pumped from the Columbia River. As a result of public concern about the potential for Hanford-associated contaminants to be present in offsite water, sampling was conducted to document the levels of radionuclides in water used by the public. Consumption of food irrigated with Columbia River water downstream from the Site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual (see Section 5.0, "Potential Radiation Doses from 1995 Hanford Operations").

Collection, Analysis, and Radiological Results for Offsite Water Samples

Grab samples were collected once from five offsite domestic water supplies at four locations during 1995. Analyses of unfiltered aliquots of the samples included gamma scan, total alpha, total beta, tritium, and uranium-234, -235, and -238. All radionuclide concentrations measured in offsite water supplies in 1995, reported by Bisping (1996), were below DOE Derived Concentration Guides (Appendix C, Table C.5) and the Washington State and EPA Drinking Water Standards (Appendix C, Table C.2). The proposed EPA Drinking Water Standard for total uranium, however, was exceeded at one location. Total uranium concentrations observed in offsite water supplies were comparable to those reported by the state of Washington elsewhere in Franklin County (DSHS 1988) and were not attributable to Hanford operations. Uranium isotopes were detected at measurable concentrations in three of the five offsite domestic water supplies. The concentrations of all other measured radionuclides in offsite drinking water during 1995 were less than two times their associated total propagated analytical uncertainties. Elevated total alpha concentrations measured in offsite water supplies in 1995 were attributable to natural uranium concentrations in the ground water.

Water in the Riverview irrigation canal was sampled three times in 1995 during the irrigation season. Unfiltered samples of the canal water were analyzed for gamma emitters, strontium-90, total alpha, total beta, tritium, and uranium-234, -235, and -238. Results are presented by Bisping (1996). In 1995, radionuclide concentrations measured in Riverview irrigation water were found to be at the same levels observed in the Columbia River. All radionuclide concentrations were below DOE Derived Concentration Guides and ambient surface water quality criteria levels. Strontium-90 was the radionuclide of most concern because it has been identified as one of the primary contributors to the calculated hypothetical dose to the public via the water pathway (Jaquish and Bryce 1989). The concentrations of strontium-90 in the irrigation water during 1995 ranged from 0.01 to 0.08 pCi/L and were similar to those reported for the Columbia River at Priest Rapids Dam and the Richland Pumphouse (see Columbia River Water subsection).